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AN ANALYSIS OF FOUR YEARS CAPTURES OF INSECTS IN A LIGHT TRAP. PART I. GENERAL SURVEY; SEX PROPORTION; PHENOLOGY; AND TIME OF FLIGHT

By C. B. Williams, Sc.D.

(*Chief Entomologist, Rothamsted Experimental Station, Harpenden.*)

(Read 19th October, 1938.)

With Plate 1 and 9 Text-Figures.

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Introductory

Previous Uses of Light Traps.

The attraction of insects to light, or more technically speaking their positive phototropic response, has been made use of for many years by students of Entomology. In the early days a light was exposed and the insects which flew to it were captured by the investigator as they arrived. Sometimes a white sheet was placed at one side of, or beneath, the light, to be illuminated by it, as it had been found that insects tend to settle on such a surface and so could be more easily examined and caught.

Soon, however, trapping devices were arranged round the light whereby the insects were either killed or prevented from escaping, so that the captures could be examined by the investigator at leisure on the following day. Such traps have been used in recent years with several different objects which may be summarised as follows.

Firstly for the collection of specimens for museums and hence the study of the fauna of special areas, the geographical distribution of insects, and as a source of material for the study of taxonomy.

Secondly as a sampling method to obtain a measure of the numbers of any species active at any particular locality or date; hence as an aid to the study of the biology of the insects; and in particular to their dates of appearance, relative length and size of broods, migration, the relation of their abundance to the conditions of the environment, and finally the study of the changes in population from place to place and from year to year: in fact what are now called studies of Ecology.

Thirdly traps have been used as a method for the wholesale destruction of insect pests, with a view to the reduction of damage caused by them.

References in literature to the use of light traps are very numerous. Mention might be made here of the papers of de Worms (1930, 1931, 1932 and 1933), Smith (1923) and Andrewes (1931), who used traps primarily for the collection of specimens; of W. C. Cook (1921–1930), who made a most excellent series of studies of the Ecology of the Noctuidae in Montana (U.S.A.) very largely from light trap records; and of Theobald (1926) and Williams (1921 : 57), who used light traps for the attempted control of Insect Pests. Bogush (1936) has recently given a short account of some of the varied results that he has obtained from continuous use of light traps in South Russia.

Object of the Present Experiments.

The observations discussed below were made primarily with the second of the above objects in view; that is, using the trap as a sampling method to give data which could be used in statistical analysis. Particularly I wished to see if any high degree of accuracy could be introduced into field observations, so as to make them comparable with, and supplementary to, the elaborate laboratory experiments carried out in recent years on the effect of single factors, such as temperature and humidity, under controlled and artificial conditions. Some day the results of this laboratory work must be combined and tested under field conditions, however difficult it is and however many mistakes are made at first.

It was also hoped that the experiments might indicate methods whereby the design and use of the light trap might be made more efficient both for scientific and economic purposes.

The collection of specimens was no part of the objects, but such rarities as have come in have been handed over to specialists or museums for identification, and a short part of the discussion below gives information thus obtained on the fauna in the neighbourhood of the trap.

So far as I am aware no comparable continued series of data has previously been collected, and a large part of the interest in the analysis consists in showing in what varied aspects of ecology, in its widest sense, information can be obtained.

The number of figures obtained in the four years work is somewhat overwhelming, but it is felt that it is better to err on this side than to follow the example of a recent worker who, having used one particular light trap for two periods of half an hour each, produced in a paper a figure for the " mean catch per hour," the " minimum catch per hour " and the " maximum catch per hour " for comparison with other traps !

The data on the relation of catch to weather conditions will be discussed in the second part of this paper.

Apparatus and Technique.

The trap used in the experiments has already been fully described (Williams 1935). The source of light is a 200-watt gas-filled clear electric light bulb at a height of about 3 feet 6 inches from the ground. The light is run in parallel with a resistance of about 700 ohms, which slightly reduces the current through the lamp and so lengthens its life. The candle power is, however, correspondingly reduced and is approximately 300.

The light is surrounded by a glass trap and the insects which enter it (partly overcome by the heat of the lamp) fall into a funnel and hence into one of a series of killing bottles. There are eight of these bottles on a turn-table and they are changed by a clockwork mechanism at predetermined intervals during the night. Owing to the continual alteration in the length of the night, the bottles are not changed at fixed hours but at fixed fractions (one-eighth) of the night. The night is assumed to start half an hour after sunset and to end half an hour before sunrise. The intervening time is divided into eight equal parts which vary in length from about 50 minutes at mid summer to just under two hours in mid winter (see fig. 7, p. 119). The change from period 4 to period 5 is always at midnight. In practice the alteration in the timing is made once a week.

A simple form of trap without the bottle-changing mechanism was first put out in the autumn of 1932, but after a few tests it was withdrawn and the present trap was started on the 1st March 1933. From that date it was in practically continuous use for four years, except that during May and June of 1936, when it was only in use two nights out of each three in a randomised test against a second trap. Records of the total catch are available on 1407 nights, but on some of these the bottle-changing mechanism was out of order, so that the night distribution was not available.

The trap was exposed on the edge of one of the experimental fields at Rothamsted, at a height of about 400 feet above sea level, on ground which is chiefly a flinty clay overlying chalk. To the east of the trap is " Barnfield," which has been under mangolds for over fifty years, and was so throughout the trap sequence except that in 1935 the crop failed completely owing to insect attack early in the year; to the west of the trap is a large pasture; to the north a small orchard of about 40 fruit trees (apple, pear and plum); to the south a tennis court and then chiefly pasture. There are rows of trees in the

vicinity, along the edges of paths and fields, which are chiefly oak, elm and lime. The location, therefore, alters little from year to year in its vegetation. Its position is about 25 miles north of London in the Chiltern Hills in the County of Hertfordshire.

The district is almost without running water and the nearest stream is about one and a quarter miles away to the west. This probably accounts for the small number of aquatic insects in the trap. About a hundred and twenty yards to the east on the opposite side of Barnfield is a small artificial cement-walled pond. Otherwise the nearest standing water consists of three small ponds on Harpenden Common about seven hundred yards away to the east and not visible from the trap.

Each morning the catch was removed from the trap and the contents of each bottle sorted into orders. Some of the orders were further sorted into families, or smaller groups, while the larger Lepidoptera were sorted to species and frequently also sexed. It was, of course, essential that any group or species dealt with should be easily recognisable from related groups.

The nomenclature of the larger Lepidoptera is, for convenience only, that of South's " Moths of the British Isles." That of the " Microlepidoptera " is based on that of Meyrick's " Revised Handbook of the British Lepidoptera."

Note on the Use of Geometric Means.

It has been shown in two previous papers (Williams 1935 and 1936) that the changes that take place in the catches are of a geometric nature; that is to say, that a catch of double the mean is as likely to occur as one of half the mean; four times the mean is as likely to occur as one-quarter of the mean, etc. In these circumstances arithmetic means give misleading results and geometric means should be used. The simplest way of doing this is to use the logarithm of the number of insects captured, instead of the number itself. The arithmetic mean of the logarithms of a series of numbers is the logarithm of the geometric mean of the series.

When a zero is included in the series it has been shown (*loc. cit.*) that a close approximation may be made by using log $(n + 1)$ instead of log n. These logs or geometric means have been used on several occasions below and will be discussed more fully in the second part.

General Survey of Captures.

Total Captures in the Different Years.

The total number of insects captured in the first year (March 1933–February 1934) was 109,346 (Table 1); in the second year (1934–35) 103,459; in the third year (1935–36) 398,905 and in the fourth year (1936–37) 241,824. In the last year, however, owing to another experiment, the trap worked only on nineteen nights in May and on the same number in June. To correct for this so as to make the figures for the four years comparable it is necessary to add approximately 50% of the catch in these two months, which makes a final total of about 257,000 insects for 1936–37.

The arithmetic mean catch per night is 287 in 1934, 310 in 1933, 728 in 1936 and 1102 in 1935, in ascending order. The geometric mean, however, gives a quite different sequence as follows: 37 in 1933; 53 in 1934; 54 in 1935; and 64 in 1936. In fact the lowest and the highest total captures (in 1934 and 1935 respectively) give two intermediate and almost identical geometric means.

This is due to the fact that the high total catch in 1935–36 was chiefly made up of a relatively small number of very large catches; for example, 73,100 on

TABLE 1.

Number of insects caught in each of 48 months with arithmetic and geometric mean catches per night.

	1933–34	1934–35	1935–36	1936–37	All years	1933–34	1934–35	1935–36	1936–37	All years
	Total catch per month					Arith. mean catch per night				
March .	518	232	1,358	628	—	20	8	45	22	24
April .	1,421	659	641	910	—	51	22	22	33	32
May .	15,368	3,118	8,183	2,624 [1]	—	549	100	263	133	261
June .	13,141	13,139	176,735	24,821 [1]	—	438	428	5,891	1,306	2,016
July .	37,521	25,482	113,253	46,057	—	1,294	822	3,653	1,486	1,819
Aug. .	18,024	12,286	59,887	105,309	—	581	410	1,996	3,631	1,855
Sept. .	6,621	9,260	15,881	37,854	—	221	309	529	1,262	580
Oct. .	6,230	10,852	11,671	11,330	—	201	351	376	378	329
Nov. .	9,414	14,872	8,603	5,768	—	314	498	287	199	325
Dec. .	500	6,615	795	1,056	—	16	213	26	36	73
Jan. .	500	5,749	1,539	1,719	—	16	198	50	55	80
Feb. .	88	1,195	359	3,848	—	3	46	13	148	53
Year .	109,346	103,459	398,905	(241,824)	—	310	287	1,102	728	607
	Mean log. catch per night					Geomet. mean catch per night.				
March .	0·97	0·56	1·13	0·87	0·88	8·3	2·6	12	6·4	6·6
April .	1·23	0·91	1·00	0·87	1·00	16	7·1	9·0	6·4	9·0
May .	2·24	1·47	1·62	1·80	1·78	173	28	41	62	59
June .	2·36	2·36	2·71	2·60	2·51	228	228	512	397	322
July .	2·74	2·78	3·15	2·78	2·86	549	602	1,412	602	723
Aug. .	2·46	2·24	2·99	3·25	2·74	287	173	976	1,777	549
Sept. .	2·19	2·17	2·37	2·81	2·39	154	147	233	645	245
Oct. .	1·66	1·99	1·96	1·84	1·86	45	97	90	68	71
Nov. .	1·91	2·18	1·73	1·79	1·90	80	150	53	61	78
Dec. .	0·57	1·94	0·88	1·02	1·10	2·7	86	6·6	9·5	11·6
Jan. .	0·41	1·25	0·85	0·97	0·87	1·6	16	6·1	8·0	6·4
Feb. .	0·30	0·92	0·51	1·14	0·72	1·0	7·3	2·2	13·7	4·2
Year .	1·58	1·73	1·74	1·81	1·72	37	53	54	64	51

[1] Trap only working on 19 days in each of these two months.

one night at the end of June and eight other nights with over 10,000 insects per night: there were also an unusually large number of nights with no catch. On the other hand, the small total numbers caught in 1934 were more evenly distributed with only one night in the whole year (that of the 7th October with a catch of 5149) over 3000 insects, and a smaller number of nights with zero catch. The number of nights in each of the four years with no catch and with over 1000 insects is shown in the following table.

TABLE 2.

Distribution of unusually large and small catches in the four years.

No. of nights with captures of insects	0	1,000 to 10,000	Over 10,000
1933–34 . . .	53	31	0
1934–35 . . .	16	31	0
1935–36 . . .	30	45	9
1936–37 . . .	29	59	4

Total Captures per Month.

Table 1 also shows the total captures per month and the mean catch per night of all insects in the trap, for each month of the four years on both arith-

metic and log basis. Fig. 1 shows, from this table, the change in the four years mean catch per night in each month of the year.

It will be seen from the figures that the numbers of insects per night is at its lowest in February on both number and log basis; and at its highest in June on the number basis (unduly weighted by very large captures in the last week of June 1935) but in July on the log basis.

The fact that the catches in the trap are at their lowest in February indicates that March, which was the month in which the trap was started in 1933,

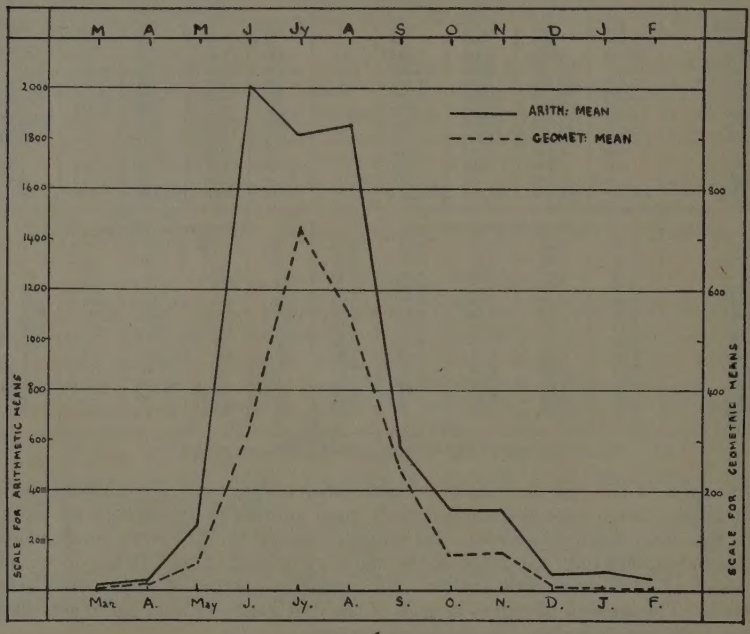

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FIG. 1.—Arithmetic and geometric mean catch per night in each month of the year; average of four years.

can be considered on an average as the beginning of insect activity in the new season. Thus the division of the trap years from March to February as used in this paper has a definite biological justification.

On the log basis, which is definitely more consistent, the order of the months in descending sequence of insect abundance is as shown in Table 3.

It will be seen that in the first four and the last two months the catches are in the same order as that of the mean minimum temperature. The autumn months have, however, values considerably higher than the spring months of the same minimum temperature, and November is out of its sequence with a higher average catch than October. This latter fact is due to the large number of "winter-gnats" (Diptera, Trichocera) which begin to emerge in October and reach their maximum in November.

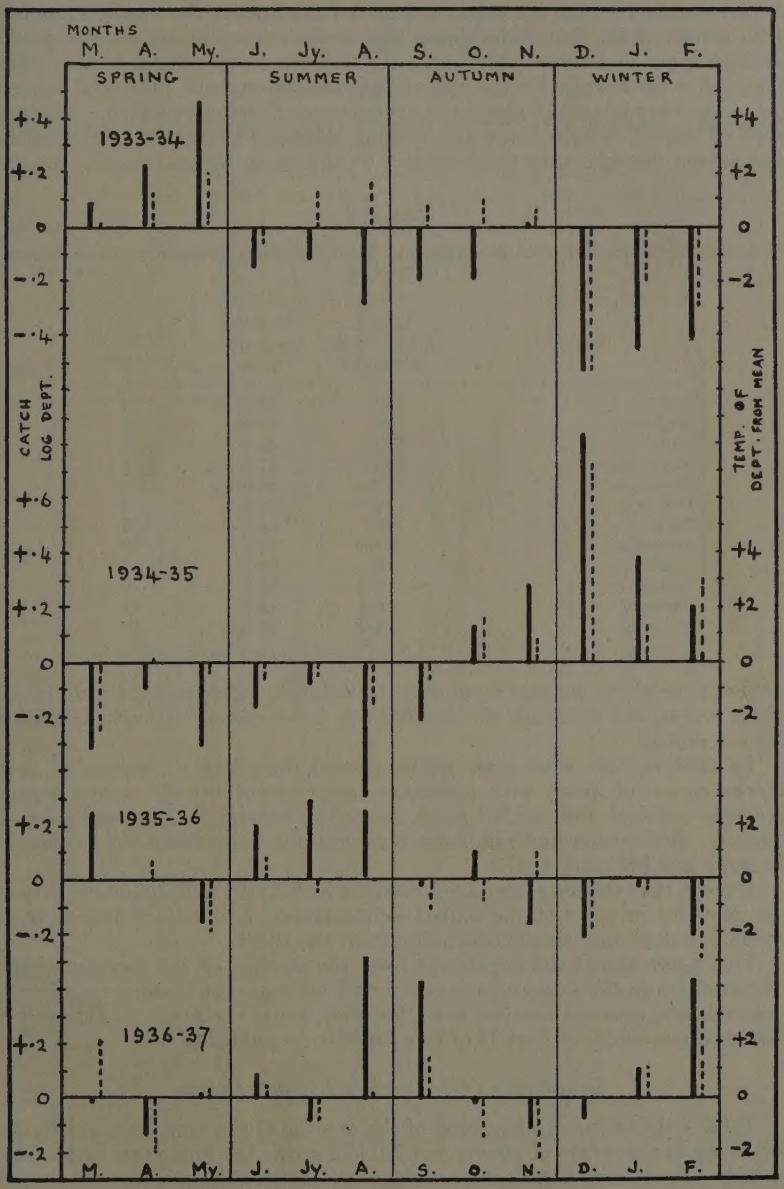

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FIG. 2.—Departure from the mean of the average log catch per night in each month, together with the departures of the minimum temperatures for comparison.

An examination of the departure of the catch from the mean throughout each month of the four years shows (fig. 2) that the numbers were above the average in the first three months that the trap was in use (March to May 1933), then below the average for the rest of 1933 and throughout 1934 until September, when they remained above the average from October to March. This long spell of sixteen months below the average corresponded with a long-continued and severe drought with temperatures on the whole above normal. In 1935

TABLE 3.

Relation between mean catch per night and mean minimum temperature in each month of the year.

Month.	Geom. mean catch per night	50 years mean min. temp.	Order of min. temp.
July	723	52·0° F.	1
August	549	51·6	2
June	322	48·4	3
September	245	47·9	4
November	78	36·6	8
October	71	42·1	6
May	59	44·1	5
December	11·6	33·2	10
April	9	37·3	7
March	6·6	34·1	9
January	6·4	32·6	11
February	4·2	32·5	12

catches were above normal from June to October, which months were on the whole warm, and although the rainfall was below normal drought conditions did not prevail.

In 1936 catches were again above normal from May to September (with the exception of June) with minimum temperatures usually above normal, sunshine deficient and rainfall much above the average in June and below in August. Both catch and minimum temperatures were above the average in January and February 1937.

Except that the long-continued drought in 1933–34 had definitely reduced the captures in spite of the higher temperatures, it does not appear to be possible to draw any simple conclusion from the above.

Fig. 3 also shows the departures from the average of the mean minimum temperatures in the same month and it will be seen that there is in general a close relation between the two with, however, some exceptions. This will be discussed more fully in Part II of this paper to be published later.

Distribution of the Catch in Different Orders.

Table 4 shows the catch in each of the months of the four years subdivided according to the orders of insects and Table 5 shows the four years mean catch of each order in each month.

It will be seen that the Diptera caught greatly outnumber all the other groups, actually constituting 86·7% of the catch in the four years and over 93% in 1936–37. The Lepidoptera are the next most abundant group constituting from 19·3% in 1934 to only 5·5% in 1936 with an average of 10·3%.

The remainder of the insects all together make up only 3% of the catch. Coleoptera in particular are unexpectedly rare, making only 0·26% of the total.

TABLE 4.

Distribution of the catch each month among the different orders of insects, with annual and four-year totals.

		Dipt.	Lepid.	Rhyn.	Hym.	Col.	Psoc.	Neur.	Trich.	Thys.	Ephem.
1933	March .	491	27	—	—	—	—	—	—	—	—
	April .	1,308	99	2	9	3	—	—	—	—	—
	May .	13,366	813	12	1,153	25	—	2	—	—	—
	June .	9,822	2,890	188	156	55	8	15	2	—	—
	July .	28,481	6,871	1,421	436	163	81	13	20	31	—
	Aug. .	10,862	2,751	3,443	461	162	266	21	23	19	2
	Sept. .	4,687	1,010	460	209	26	175	21	13	15	—
	Oct. .	5,666	307	165	55	5	19	—	6	3	—
	Nov. .	9,296	91	8	15	5	—	—	—	—	—
	Dec. .	471	27	—	—	—	—	—	—	—	—
1934	Jan. .	500	—	—	—	—	—	—	—	—	—
	Feb. .	75	12	—	1	—	—	—	—	—	—
	March .	217	13	—	—	2	—	—	—	—	—
	April .	549	67	1	—	39	—	—	—	1	—
	May .	2,660	253	3	68	119	—	7	—	9	—
	June .	7,525	4,850	496	124	75	28	37	1	7	—
	July .	12,847	10,844	989	424	173	40	43	14	90	1
	Aug. .	8,477	2,657	532	268	100	195	20	3	29	—
	Sept. .	5,332	854	2,402	223	52	381	10	7	3	—
	Oct. .	9,808	192	725	39	24	26	12	13	1	—
	Nov. .	14,651	199	5	7	4	2	2	1	—	—
	Dec. .	6,527	29	2	2	50	—	2	—	—	—
1935	Jan. .	5,726	5	—	1	11	1	1	—	1	—
	Feb. .	1,192	1	—	—	2	—	—	—	—	—
	March .	1,324	33	—	—	1	—	—	—	—	—
	April .	578	37	—	2	24	—	—	—	—	—
	May .	7,774	307	8	56	42	—	1	—	1	—
	June .	169,594	6,541	265	182	132	2	4	4	—	2
	July .	89,424	22,579	510	352	309	7	23	4	33	1
	Aug. .	47,313	9,426	2,070	730	239	2	34	49	6	4
	Sept. .	14,423	860	273	199	33	2	6	12	1	—
	Oct. .	11,454	187	22	44	14	7	3	7	—	—
	Nov. .	8,548	29	8	6	6	—	—	3	—	—
	Dec. .	783	11	—	—	1	—	—	—	—	—
1936	Jan. .	1,529	9	1	2	1	—	—	—	—	—
	Feb. .	354	4	—	1	—	—	—	—	—	—
	March .	596	23	—	—	13	—	—	—	—	—
	April .	867	30	1	4	8	—	—	—	—	—
	May .	2,206	213	2	40	54	—	2	—	8	—
	June .	20,659	3,836	79	167	72	—	—	2	3	—
	July .	40,810	4,962	83	102	67	1	3	15	11	—
	Aug. .	101,748	3,044	157	260	59	—	19	20	2	—
	Sept. .	36,054	952	435	312	36	14	13	30	—	—
	Oct. .	11,162	72	28	54	1	1	3	7	—	—
	Nov. .	5,726	30	4	6	2	—	—	—	—	—
	Dec. .	1,037	17	—	—	2	—	—	—	—	—
1937	Jan. .	1,713	2	—	—	4	—	—	—	—	—
	Feb. .	3,846	1	—	—	1	—	—	—	—	—
1933–34 Total .		85,025	14,898	5,699	2,495	444	549	72	64	68	2
	Per cent.	77·8	13·6	5·2	2·3	0·4	0·5	0·06	0·05	0·06	0·002
1934–35 Total .		75,511	19,964	5,155	1,156	651	673	134	39	141	1
	Per cent.	73·0	19·3	4·9	1·1	0·6	0·7	0·13	0·04	0·14	0·001
1935–36 Total .		353,098	40,023	3,157	1,574	802	20	76	79	41	7
	Per cent.	88·5	10·0	0·8	0·4	0·2	0·005	0·02	0·02	0·01	0·002
1936–37 Total .		226,424	13,182	789	945	319	16	40	74	24	—
	Per cent.	93·6	5·5	0·33	0·39	0·13	0·007	0·016	0·03	0·01	—
All Years Total		740,058	88,067	14,800	6,170	2,216	1,258	322	256	274	10
	Per cent.	86·7	10·3	1·73	0·72	0·26	0·15	0·04	0·03	0·03	0·001

The two rarest groups were the Trichoptera with 256 individuals in the four years and the Ephemeroptera with only 10. Both of these groups are aquatic and the absence of water in the neighbourhood (see p. 82) probably accounted for the low numbers.

The Rhynchota, which together made up 1·73% of the total, included

TABLE 5.

Distribution of the catch among the different orders of insects; average for each month of the four years.

	Dipt.	Lepid.	Rhyn.	Hym.	Col.	Psoc.	Neur.	Trich.	Thys.	Ephem.
March .	654	24	—	—	4	—	—	—	—	—
April .	825	58	1	4	18	—	—	—	0·3	—
May .	6,501	396	6	329	60	—	3	—	5	—
June .	**51,900**	4,529	257	157	83	10	14	2	3	0·5
July .	42,890	**11,314**	751	328	**178**	32	22	13	**41**	0·5
Aug. .	42,100	4,469	**1,551**	**430**	140	116	**24**	**24**	16	0·3
Sept. .	15,124	919	893	236	37	**143**	12	16	5	—
Oct. .	9,522	190	235	48	11	13	4	8	1	—
Nov. .	9,555	87	6	9	4	0·5	0·5	1	—	—
Dec. .	2,205	21	0·5	0·5	13	—	0·5	—	—	—
Jan. .	2,367	4	0·3	0·8	4	0·3	0·3	—	0·3	—
Feb. .	1,367	5	0·5	0·8	—	—	—	—	—	—

numbers of APHIDIDAE and JASSIDAE and also many CAPSIDAE, with smaller numbers of other families.

The Neuroptera (0·04% of the total) included chiefly CHRYSOPIDAE and HEMEROBIIDAE (see Williams and Killington 1935 and p. 97) with small numbers of CONIOPTERYGIDAE.

No Orthoptera, Mecoptera, Plecoptera, Odonata or Strepsiptera came into the trap. Numbers of earwigs (Dermaptera) were found in the killing bottles at times, but they are not tabulated as it was considered uncertain that they had either been attracted to the light or had entered the trap by flying.

Turning to the average monthly distribution of the groups (Table 5), it will

TABLE 6.

Species of SPHINGIDAE, NOTODONTIDAE, etc., captured in the trap in the four years.

	1933	1934	1935	1936		1933	1934	1935	1936
SPHINGIDAE					NOLIDAE				
D. tiliae . . .	—	1	—	—	*N. cuculatella* . .	5	40	12	3
S. populi . . .	—	2	3	1	CHLOEPHORIDAE				
S. ocellatus . . .	2	1	—	—	*H. prasinana* . .	—	—	1	—
NOTODONTIDAE					SARROTHRIPINAE				
C. bifida . . .	—	—	2	1	*S. revayana* . .	—	—	—	1
D. trimacula . .	—	—	4	—	ARCTIIDAE				
P. tremula . . .	6	3	17	2	*S. menthastri* . .	179	126	83	76
N. ziczac . . .	1	2	1	1	*S. lubricipeda* . .	100	73	40	33
N. dromedarius . .	—	1	—	—	*D. mendica* . .	9	15	7	5
L. camelina . .	3	1	4	1	*P. fuliginosa* . .	2	1	1	—
P. palpina . .	—	3	4	1	*A. caja* . . .	8	5	15	8
P. bucephala . .	7	5	33	4	*H. jacobaeae* . .	14	6	2	15
THYATIRIDAE					LITHOSIIDAE				
H. derasa . . .	7	7	15	3	*C. senex* . . .	—	4	1	—
T. batis . . .	1	1	1	—	*L. luridcola* . .	99	138	64	32
P. octogesima . .	1	—	4	—	*L. lutarella* . .	—	1	—	—
A. diluta . . .	1	—	—	—	HYPENIDAE				
LYMANTRIIDAE					*Z. tarsipennalis* . .	—	3	—	1
D. pudibunda . .	—	—	4	2	*Z. grisealis* . . .	—	1	—	—
P. similis . . .	77	40	51	22	*H. proboscidalis* . .	7	2	—	1
S. salicis . . .	—	1	2	—	HEPIALIDAE				
LASIOCAMPIDAE					*H. humuli* . . .	2	1	—	—
M. neustria . . .	38	41	69	3	*H. sylvina* . . .	7	8	48	15
T. crataegi . . .	2	1	—	3	*H. lupulinus* . .	16	20	115	36
P. populi . . .	51	38	28	24	COSSIDAE				
C. potatoria . .	26	13	12	3	*Z. pyrina* . . .	—	—	1	—
G. quercifolia . .	—	1	2	1					
DREPANIDAE					No. of individuals . .	704	635	671	309
D. binaria . . .	4	9	3	6	No. of species . .	28	36	33	29
C. glaucata . . .	29	20	22	5					

be seen that the Diptera occurred regularly in all months of the year with a maximum in June. The Lepidoptera reached a maximum in July and were rare in the winter months. The Rhynchota had their maximum in August and were practically absent from December to April inclusive.

The Hymenoptera reached their maximum in August and were practically absent from December to April. The large catch of Hymenoptera in May 1933 was almost all CYNIPIDAE (probably from neighbouring oak trees) but no similar flight occurred in the other years. Coleoptera appeared in all months with a maximum in July. Psocoptera had a late maximum in September, and were practically absent from November to May. Neuroptera had their maximum in July and August, and were practically absent from November to April.

TABLE 7.

NOCTUIDAE.

Species of NOCTUIDAE captured in the trap in the four years.

	1933	1934	1935	1936		1933	1934	1935	1936
D. coryli	3	—	—	1	*P. flavicincta*	—	1	—	—
A. psi	3	2	1	—	*B. sphinx*	1	3	3	1
A. rumicis	1	—	1	—	*M. oxyacanthae*	2	2	3	3
B. perla	2	—	1	3	*E. lucipara*	—	—	1	—
A. segetum	—	3	6	1	*P. meticulosa*	1	—	16	2
A. cinerea	1	—	—	—	*H. nictitans*	3	3	18	5
A. puta	1	15	39	2	*H. micacea*	16	16	20	21
A. nigricans	—	1	1	1	*O. ochracea*	—	1	2	2
A. exclamationis	110	165	1799	275	*T. fulva*	—	—	—	1
A. ypsilon	—	—	1	—	*L. pallens*	93	65	48	5
A. strigula	—	—	1	—	*L. impura*	51	75	58	42
A. saucia	1	—	—	—	*L. comma*	15	9	61	11
A. ravida	—	1	—	—	*L. lithargyria*	2	15	33	1
N. augur	8	6	6	—	*L. conigera*	20	28	64	8
N. c-nigrum	60	82	323	107	*G. trigrammica*	6	14	53	11
N. primulae	21	24	38	16	*C. morpheus*	10	13	29	12
N. rubi	88	99	40	8	*C. alsines*	10	22	87	10
N. umbrosa	10	6	5	1	*C. taraxaci*	—	1	21	12
N. xanthographa	211	100	173	105	*P. arcuosa*	6	22	20	10
N. triangulum	—	—	2	—	*R. tenebrosa*	29	22	73	24
N. plecta	5	4	3	1	*A. pyramidea*	—	—	1	—
A. putris	3	3	6	—	*A. tragopogonis*	3	—	5	5
T. comes	—	—	7	—	*P. rubricosa*	1	—	1	1
T. pronuba	12	4	34	4	*T. gothica*	54	48	34	13
T. ianthina	1	—	5	—	*T. pulverulenta*	1	5	1	—
A. advena	2	—	3	—	*T. stabilis*	1	5	4	—
B. brassicae	3	1	—	1	*T. incerta*	2	1	10	—
M. persicariae	8	12	28	1	*T. gracilis*	2	—	2	—
M. oleracea	—	—	3	2	*D. oo*	1	—	—	—
M. genistae	—	—	1	—	*C. pyralina*	—	2	5	—
M. pisi	2	—	1	1	*C. affinis*	2	2	1	1
M. dentina	—	2	17	1	*C. trapezina*	3	8	6	1
D. conspersa	1	1	2	—	*P. subtusa*	2	—	—	—
D. cucubali	3	1	4	—	*C. xerampelina*	—	—	1	—
D. carpophaga	2	10	6	2	*A. lunosa*	60	159	200	141
H. serena	3	4	8	2	*A. iota*	—	—	1	—
N. reticulata	2	1	2	2	*A. circellaris*	1	1	—	—
E. popularis	34	109	132	30	*A. lychnidis*	329	219	232	43
T. cespitis	4	15	13	13	*A. litura*	2	1	—	5
C. graminis	9	16	7	4	*O. aurago*	—	—	—	3
E. adusta	9	3	1	—	*M. gilvago*	9	9	2	3
E. protea	3	—	—	—	*O. vaccinii*	4	8	6	—
B. viminalis	—	—	2	—	*O. ligula*	1	9	5	—
D. caeruleocephala	7	—	—	2	*E. satellita*	—	1	—	—
L. testacea	46	153	294	111	*X. areola*	—	—	—	1
C. matura	38	33	75	53	*C. verbasci*	—	—	1	—
H. sordida	3	—	21	2	*C. umbratica*	—	—	1	—
A. gemina	5	3	5	3	*A. luctuosa*	1	7	14	3
B. basilinea	7	4	7	1	*P. moneta*	1	—	—	—
A. secalis	41	25	223	17	*P. chrysitis*	3	2	1	—
M. strigilis	36	15	51	10	*P. iota*	1	—	—	—
M. fasciuncula	29	32	88	32	*P. gamma*	2	8	17	24
M. literosa	—	1	3	1	*A. tripartita*	1	—	2	1
M. bicoloria	2	23	139	80	*C. nupta*	—	—	1	—
X. lithoxylea	10	18	9	6					
X. monoglypha	30	90	603	20	Total	1636	1894	5412	1362
D. scabriuscula	—	—	1	1					
A. lutulenta	4	—	8	13	No. of species	84	73	94	71

Diptera, Lepidoptera, Coleoptera, Trichoptera and Ephemeroptera were most abundant in 1935. Rhynchota and Hymenoptera in 1933. Psocoptera, Thysanoptera and Neuroptera in 1934.

All groups except Diptera and Trichoptera were least abundant in 1936. Diptera and Trichoptera were least abundant in 1933.

There is no evidence from gross numbers of insects that the trap is causing any reduction in the insect population in the area from which it draws its captures.

The Species of Lepidoptera Captured in the Trap.

Tables 6 to 10 show all the species of Lepidoptera captured in the trap which were identified, with the number of each captured in each of the four years. The following points about identification must be noted.

Table 8.

Geometridae.

Species of Geometridae captured in the trap in the four years.

	1933	1934	1935	1936		1933	1934	1935	1936
P. pruinata	9	21	17	11	*A. nigrofasciaria*	5	5	6	—
G. papilionaria	3	3	5	—	*A. luteata*	3	—	4	1
E. pustulata	17	8	2	1	*E. oblongata*	26	87	52	4
I. lactearia	8	1	5	—	*E. venosata*	2	2	3	2
H. strigata	11	2	8	1	*E. succentauriata*	3	5	1	—
A. virgularia	—	—	3	—	*E. subfulvata*	6	13	31	15
A. aversata	17	39	41	12	*E. exiguata*	3	—	—	—
A. bisetata	17	3	21	2	*C. coronata*	9	7	1	1
A. dimidiata	—	—	10	3	*P. comitata*	3	—	1	—
A. imitaria	1	4	4	—	*P. fluviata*	—	—	—	1
A. emarginata	—	1	—	—	*A. grossulariata*	35	16	20	18
T. amata	17	14	25	11	*L. marginata*	2	2	6	1
O. plumbaria	18	4	9	6	*L. adustata*	1	4	—	—
O. cervinata	5	6	4	—	*B. bimaculata*	1	—	—	—
O. limitata	20	6	12	6	*B. temerata*	—	—	2	—
A. plagiata	—	—	3	—	*C. exanthemata*	8	4	10	1
C. spartiata	—	2	—	1	*M. margaritaria*	2	4	7	1
L. viretata	1	—	—	—	*E. quercinaria*	—	—	1	1
C. brumata	48	145	6	22	*E. alniaria*	—	3	21	5
T. dubitata	2	1	—	1	*E. fuscantaria*	12	13	20	15
E. silaceata	—	—	1	—	*S. bilunaria*	22	10	13	7
L. prunata	—	—	2	—	*S. lunaria*	6	6	3	—
L. testata	—	—	—	1	*S. tetralunaria*	—	—	2	1
L. associata	1	2	1	—	*H. syringaria*	1	—	2	—
C. pyraliata	27	32	52	11	*G. bidentata*	4	2	5	1
C. fulvata	19	29	10	2	*H. pennaria*	8	5	1	1
C. truncata	14	1	—	8	*C. elinguaria*	7	17	14	13
C. immanata	14	1	4	—	*O. sambucaria*	3	1	2	—
C. miata	—	—	1	1	*E. dolabraria*	—	—	2	2
T. obeliscata	2	3	1	3	*O. luteolata*	73	44	40	20
C. unidentaria	197	48	29	8	*H. rupicapraria*	1	15	3	1
C. ferrugata	104	19	7	5	*H. marginaria*	4	14	8	2
C. designata	1	—	—	—	*H. defoliaria*	9	13	1	1
A. viridaria	—	5	—	—	*A. aescularia*	21	23	2	5
M. multistrigaria	2	8	6	—	*P. pedaria*	—	1	—	1
M. didymata	3	8	16	—	*L. hirtaria*	1	2	4	1
O. dilutata	48	5	6	17	*P. strataria*	1	—	2	—
X. montanata	37	2	11	3	*P. betularia*	4	3	23	4
X. fluctuata	58	40	105	36	*H. abruptaria*	3	—	—	1
X. sociata	20	—	2	3	*B. gemmaria*	4	8	5	—
X. unangularia	3	1	1	1	*T. wauaria*	3	2	1	—
M. ocellata	2	3	12	—	*L. petraria*	3	2	2	—
P. alchemillata	144	5	5	—	*S. clathrata*	21	21	14	5
C. bilineata	—	8	9	4					
H. furcata	9	9	18	13	No. of individuals	1220	853	810	324
A. badiata	21	10	11	2	No. of species	71	67	75	57

In the Bombyces, Sphingidae, and related families (Table 6) and in the Noctuidae (Table 7) practically every individual was identified, except for an occasional specimen which was too rubbed to make any reliable identification possible.

In the GEOMETRIDAE (Table 8) all specimens were identified with the exception of a number belonging to the genus *Eupithecia*. The species in this genus are very difficult to identify rapidly. Five easily recognisable species only were identified, but the others were not.

TABLE 9.

Species of PYRALIDIDAE and CRAMBIDAE captured in the trap in the four years.

	1933	1934	1935	1936		1933	1934	1935	1936
PYRALIDIDAE					CRAMBIDAE				
Cleidobia angustalis	—	—	—	1	*Schoenobius forficellus*	4	—	2	—
Pyralis costalis	44	50	109	38	*Crambus pratellus*	73	3	637	[1]
Pyralis glaucinalis	41	12	5	2	*Crambus pascuellus*	20	31	5	[1]
Nomophila noctuella	3	3	5	1	*Crambus perlellus*	208	476	564	302
Pyrausta purpuralis	1	9	4	2	*Crambus tristellus*	815	1,792	3,979	633
Herbula cespitalis	—	5	3	—	*Crambus geniculeus*	—	2	51	—
Endotrycha flammealis	—	—	3	1	*Crambus culmellus*	[1]	[1]	4,132	[1]
Eurrhypara urticalis	17	11	22	8	*Crambus hortuellus*	[1]	[1]	12,551	[1]
Scopula lutealis	—	18	26	4	*Myelophila cribrum*	—	1	2	—
Scopula olivalis	—	18	7	5	*Homoeosoma sinuella*	—	—	50	—
Scopula prunalis	20	3	8	5	*Homoeosoma binaevella*	2	1	8	3
Botys ruralis	40	49	61	26	*Euzophera pinguis*	5	3	16	1
Ebulea sambucalis	1	6	8	2	*Nephopteryx spissicella*	—	—	2	1
Spilodes verticalis	17	31	55	7	*Rhodophaca advenella*	4	1	—	2
Pionea forficalis	99	79	65	40	*Oncocera ahenella*	2	3	13	1
Paraponyx stratiotalis	—	—	2	1	*Aphomia sociella*	15	6	16	4
Hydrocampa stagnalis	—	—	1	1					

[1] Species not identified in these years.

In the PYRALIDIDAE (Table 9) the same remarks apply to the genus *Scoparia*. Practically all PYRALIDIDAE were identified except those belonging to this difficult genus.

TABLE 10

Species of TORTRICIDAE, TINEIDAE, etc., captured in the trap in the four years.

	1933	1934	1935	1936		1933	1934	1935	1936
TORTRICIDAE					TORTRICIDAE (*continued*)				
Lozoptera francillana	2	6	—	1	*Eucosma nigromaculana*	1	—	—	—
Phalonia cnicana	3	1	—	—	*Eucosma tripunctana*	1	1	37	—
Phalonia flaviciliana	5	12	1	—	*Argyroploce vairegana*	89	65	31	—
Phalonia dubitana	17	11	61	136	*Argyroploce purpurana*	24	22	31	1
Chlidonia baumanniana	1	—	3	—	*Argyroploce striana*	181	325	306	75
Euxanthis zoegana	11	16	18	5	*Argyroploce lacunana*	187	131	112	9
Euxanthis hamana	47	90	220	14	*Laspeyresia pomonella*	2	—	1	—
Cacoecia podana	33	30	24	—	TINEIDAE				
Cacoecia xylosteana	2	3	—	—	*Carcina quercana*	29	32	31	10
Pandemis corylana	4	—	3	—	*Hyponomeuta 20-punctata*	131	48	110	4
Pandemis ribeana	22	10	7	1	*Hyponomeuta cognatella*	5	9	3	5
Tortrix viridana	27	10	5	1	*Cerostoma xylostella*	4	8	1	2
Tortrix forsterana	—	—	1	—	*Cerostoma scabrella*	1	—	—	—
Argyrotoza forskaleana	10	6	4	—	*Plutella maculipennis*	376	525	1252	348
Argrotoza bergmanniana	45	34	12	—	PTEROPHORIDAE				
Peronea holmiana	9	8	—	7	*Platyptilia gonodactyla*	22	5	2	13
Peronea contaminana	14	19	1	6	*Platyptilia pallidactyla*	—	10	11	3
Peronea schulleriana	4	1	—	—	*Alucita pentadactyla*	9	22	30	5
Peronea variegana	53	—	21	6	*Pterophorus monodactylus*	19	81	57	5
Ancyles lundana	103	15	—	2	*Stenoptilia pterodactyla*	5	—	4	—
Notocelia uddmanniana	4	7	20	—	*Orneodes hexadactyla*	4	—	2	—
Notocelia roborana	142	174	169	28					

In the CRAMBIDAE an effort was made to identify all specimens in 1935, but in the other years only the more conspicuous species were identified.

In the smaller Lepidoptera only a small selection of easily recognised forms were identified in any year.

The number of species caught in the traps during the four years in each of

the main groups of Macrolepidoptera are shown in Table 11, together with the number of these groups known to have been found in the British Isles and also those known to have occurred in the County of Hertfordshire, in which Rothamsted is situated.

TABLE 11.

Relation of the number of species captured in the trap to the total number of species in the British Fauna and the Fauna of Hertfordshire.

	Spp. in trap	British spp.		Hertford spp.	
		No.	% caught	No.	% caught
SPHINGIDAE, Bombyces, etc. .	44	146	30·1	78	56
NOCTUIDAE	112	312	35·9	204	55
GEOMETRIDAE (excl. *Eupithecia*).	83	223	37·2	180	46
PYRALIDIDAE (excl. *Scoparia*) .	17	58	29·3	—	—
Total . . .	256	739	34·7	—	—

It will be seen that in one single light trap, never moved from one position (a position which was not selected as being particularly a " good " location for insects, and which is decidedly open and unsheltered), individuals of over one-third of all the known species of British Macrolepidoptera have been captured in four years.

The proportion in the different families is very similar, varying from approximately 30% in the PYRALIDIDAE to 37% in the GEOMETRIDAE.

The percentage of the known Hertfordshire species is of course higher, but rather different in constitution. Fifty per cent. or more have been captured of the known NOCTUIDAE, and BOMBYCIDAE and other related families, but only 46% of the known GEOMETRIDAE. This smaller proportion of GEOMETRIDAE may be due to the exposed position of the trap.

An interesting analysis can be made to study the relative stability of the different insects in the neighbourhood by separating the species into those which have occurred in all four years; in three years; in two years; and in one year only. This is shown in Table 12.

TABLE 12.

Frequency of occurrence of the species of Macrolepidoptera in the four years.

Distribution of species of Lepidoptera in different years.

	Bombyces		NOCTUIDAE		GEOMETRIDAE		PYRALIDIDAE		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total species captured .	44	—	112	—	89	—	17	—	262	—
In all 4 years	20	46	48	43	41	46	10	59	119	45
In 3 years.	7	16	28	25	23	26	2	12	60	23
In 2 years.	8	18	10	9	12	13	4	24	34	13
In 1 year only .	9	21	26	23	13	15	1	6	49	19

The percentage of species occurring in all four years is very similar and round about 45% in the Bombyces etc., NOCTUIDAE and GEOMETRIDAE, but is much higher (58·8%) in the PYRALIDIDAE. The percentage of species occurring in only a single year varies from 23% in the NOCTUIDAE down to only 5·9% in the PYRALIDIDAE. (For comparative figures in the CAPSIDAE see Table 16, p. 96.)

Evidence of Reduction of the Numbers of any Species by the Trap.

An examination of the figures in Tables 6 to 10 fails to give any indication of a definite reduction in the numbers in any species, which might be ascribed to the action of the trap, except possibly in the case of the Geometrid moth *P. alchemillata*. In this insect the numbers captured in the four successive years were 144 : 5 : 5 : 0. No other species even reached anything like so high a total as 144 in one year and yet failed to occur in all the other years. *P. alchemillata* was indeed the second most abundant Geometrid moth in the trap in 1933.

P. alchemillata feeds on the seed capsules of Hemp-nettle (*Galeopsis tetrahit*) which is widely distributed but not usually abundant in the district. There is no evidence available as to whether this plant was unusually abundant in the neighbourhood of the trap in 1930, as no special attention was paid to this insect at that time.

It is possible, therefore, but not proved, that the trap has caused a rapid reduction in the numbers of this one moth.

Species Captured at Rothamsted in a Second Light Trap.

The above tables are all confined to the species that were captured in the single routine trap, the light of which is at a height of 3 feet 6 inches from the ground. In addition to this trap a second light trap was in use on several occasions at a height of 35 feet above the ground. In 1933 and 1934 it was in use only in the autumn on the roof of a building. In 1935 it was in use throughout the summer, and in 1936 in May and June only, on a tripod immediately above the standard trap (see plate 1). Several species of NOCTUIDAE came to this high-level trap which were not recorded in the lower one, and some others came more abundantly at the high level. These are shown in Table 13.

TABLE 13.

Species of NOCTUIDAE which occurred only in the upper trap or which occurred more frequently in the upper than the lower trap.

Species in upper trap only.

Acronycta megacephala	1 in 1933.
Triphaena fimbria	1 in 1934.
Senta maritima	1 in 1935.
Caradrina quadripunctata	2 in 1933.
Calymnia diffinis	2 in 1933 and 1 in 1934.
Xanthia fulvago	1 in 1933 and 1 in 1934.
Cucullia chamomillae	1 in 1935.

Species more abundant in upper trap.

Agrotis saucia	11	in upper trap,	1	in lower.
Polia flavicincta	15	„ „	1	„
Cirrhoedia xerampelina	11	„ „	1	„
Orthosia lota	4	„ „	1	„
Amathes circellaris	26	„ „	2	„

Captures of Lepidoptera with Light Traps by other Workers.

Many other workers have at times used light traps for collecting moths, and there are given in Table 14 some results which may be interesting to note here owing to the relatively long periods over which they were continued.

From 1929 to 1932 C. G. M. de Worms put out a light trap on a large number of nights during the summer at Egham in Surrey, England. In every year he caught more individuals and more species of GEOMETRIDAE than of NOCTUIDAE.

In 1936 S. B. Hodgson put out a light trap on 43 nights from May to October in a beech wood on the Chiltern hills, about 11 miles W.S.W. from Harpenden on the same range of chalk hills. He caught four times as many individuals and nearly three times as many species of GEOMETRIDAE as of NOCTUIDAE.

TABLE 14.

Summary of captures of Lepidoptera in light traps by some other workers.

	Egham, Surrey (de Worms)								Chilterns (Hodgson)	
	1929 213 nights		1930 203 nights		1931 131 nights		1932 190 nights		1936 43 nights	
	spp.	indiv.	spp.	indiv.	spp.	indiv.	spp.	indiv.	spp.	indiv.
SPHINGIDAE .	1	1	1	2	—	—	2	2	—	—
Bombyces .	23	243	29	226	24	234	21	345	19	369
NOCTUIDAE .	52	270	48	358	58	289	50	188	24	202
GEOMETRIDAE	65	279	68	431	75	455	78	592	67	884
HEPIALIDAE .	3	47	1	35	3	22	1	1	2	31
Total .	144	840	147	1052	160	1000	152	1128	112	1486
Indiv. per night .	—	3·9	—	5·2	—	7·6	—	7·4	—	13·3

Both these results are quite different from mine.

Hodgson's results can be partly explained I believe by the fact that he usually stopped his lamp at or before 1 a.m. (G.M.T.), while I have shown (Williams 1935) that the GEOMETRIDAE are, on an average, earlier flyers than the NOCTUIDAE and that the latter reach their maximum activity after midnight.

It is possible also that the sheltered condition in a beech wood would be more favourable for the flight of local GEOMETRIDAE, and that the light would be less likely to be seen by the more powerfully flying NOCTUIDAE.

Species of Lepidoptera of Special Interest Caught in Trap.

The following species captured seem worthy of special note.

LYMANTRIIDAE.

Stilpnotia salicis. One male captured on 12th July 1934 in period 6. Seldom recorded in recent years in Hertfordshire. The caterpillar feeds on poplar.

LITHOSIIDAE.

Comacla senex. Four captured in 1934 on the 6th, 9th and 17th July and one male in 1935 on 10th July. Very scarce in Hertfordshire, and no previous

record for over 30 years. The larvae feed on lichens and mosses growing on the ground in marshes and fens. Possibly came from the Lee Valley about 2 miles away.

Lithosia lutarella. One male on 21st July 1934 in period 7. Not previously known to occur in Hertfordshire. A most unexpected capture, as the normal habitat of the species is on the sea coast. The nearest coast from Harpenden is the Essex coast, at least fifty miles away, and the nearest localities where I can find that the species has been recorded are on the Kent and Norfolk coasts, at least 75 miles away.

NOCTUIDAE.

Agrotis cinerea. One male captured on 18th May 1933 in the 5th period. Apparently scarce in this part of Hertfordshire. Usually found in chalk or limestone districts, which, however, are not uncommon within 10 miles, as for example the chalk downs at Dunstable.

Miana literosa. One male in 1934, three females in 1935 and one male in 1936; all in August. Very few records in the Hertfordshire list. Generally common on the coast but rarer inland.

Senta maritima. One captured on 24th June 1935 in the upper light trap on a tripod 35 feet above the ground, immediately above the standard trap. The caterpillar feeds on the stems of reeds and is chiefly found in the fens of Cambridge and Norfolk. It had previously only once been recorded in Hertfordshire, from Tring, which is about 12 miles away.

Tapinostola fulva. One male on 24th August 1936 in 3rd period of night. Very local and scarce in Hertfordshire. The caterpillar feeds on the stems of sedges (*Carex*) and is found chiefly in fenland and marshy ground.

Dicycla oo. One male on 29th June 1933. Scarce and local in Hertfordshire. Larva feeds on oaks, of which there are many trees in the immediate neighbourhood of the trap.

Calymnia pyralina. Two in 1934 and five in 1935. Not common in Hertfordshire.

GEOMETRIDAE.

Percnoptilota fluviata. One captured on 3rd September 1936. Only one other known to have been captured in Hertfordshire since 1908.

TORTRICIDAE.

Phalonia flaviciliana. Five captured in 1933 (1 in June and 4 in August), twelve in 1934 (1 in June, 3 in July, and 8 in August) and one in July 1935. Not previously recorded in Hertfordshire. The larvae feed in the flower heads of *Knautia.* Since its discovery in the trap Mr. J. C. F. Fryer has found larvae in Harpenden and has bred them to the adult stage.

Heteroptera.

Mr. D. C. Thomas has kindly identified the Heteroptera caught in the trap during the four years and has published a short paper on the group (Thomas 1938). The total captures in each family are shown in Table 15.

The CAPSIDAE are the dominant group with 57 species and 1406 individuals out of a total of 1477 Heteroptera.

TABLE 15.

Summary of species of Heteroptera captured in the trap in the four years.

	1933		1934		1935		1936		All years	
	spec.	ind.	spec.	ind.	spec.	ind.	spec.	ind.	spec.	ind.
PENTATOMIDAE	0	0	1	1	0	0	1	1	2	2
LYGAEIDAE	0	0	1	1	1	1	1	1	2	3
TINGIDAE	0	0	0	0	0	0	1	1	1	1
NABIDIDAE	2	3	2	3	3	9	1	1	3	16
ANTHOCORIDAE	1	4	1	1	1	1	1	1	2	7
CAPSIDAE	26	341	38	482	24	436	23	147	57	1406
CORIXIDAE	5	28	2	8	3	6	0	0	7	42

The distribution of the 57 species in the four years is very different from that of the NOCTUIDAE as shown in Table 16.

TABLE 16.

CAPSIDAE.

Frequency of occurrence of the species of CAPSIDAE in the different years.

	No. of spp.	% spp.
In all 4 years	10	17·5
In 3 years	6	10·5
In 2 years	12	21·1
In 1 year only	29	50·9
Total	57	100

It will be seen that half the species of CAPSIDAE only occurred in a single year, and only about one-sixth in all four years. In the NOCTUIDAE, on the contrary, less than one-quarter only occurred in a single year and 43% in all four years.

There appears to be a very high proportion of " rare species " in the CAPSIDAE, though it is difficult at present to suggest a reason for this.

The total number of known species of CAPSIDAE in Great Britain is 177, so that the 57 species captured represent 32% of the total. This is very similar to the figure of 34% for the Macrolepidoptera.

Among the CAPSIDAE the most interesting species captured was *Plesiodema pinetellum* Zett., of which fourteen males and one female were caught in 1936, although none was taken in any other year. It is a species living in *Pinus*, and up to this time was only known from Scotland and from the extreme north of England.

In the ANTHOCORIDAE one specimen of *Elatophilus nigricornis* Zett. was captured in 1935. This is also a *Pinus*-inhabiting species, and was the first recorded capture of the insect in the south of England.

The nearest *Pinus* to the trap is about 150 yards away to the south-west in a clump of trees in the middle of a pasture. The species is *Pinus sylvestris*. Several other trees occur within a short distance.

Neuroptera.

The Neuroptera captured in the trap in the autumn of 1932 and in 1933 and 1934 were identified by Mr. F. J. Killington, and a detailed account has been published (Williams and Killington 1935).

The captures included six species of HEMEROBIIDAE and five of CHRYSOPIDAE.

In the HEMEROBIIDAE there were two rare and local species: *Sympherobius pygmaeus* (Ramb.), of which six were captured, and *Sympherobius elegans* (Steph.), of which one male only came in June 1933.

In the CHRYSOPIDAE the most interesting capture was one male of *Chrysopa phyllochroma* Wesm., a very rare species, on 24th August 1933.

THE SEX RATIO IN THE TRAP.

It must be understood that the discussion below applies to the actual insects caught and not to the field population from which the samples are taken by the trap.

The Normal Sex Proportions in the Trap.

Lepidoptera.

Fifty-one species of NOCTUIDAE came into the trap in sufficient numbers in the four years to give a reasonable estimate of the sex proportions. These are shown in Table 17.

TABLE 17.

Sex ratio of species of NOCTUIDAE in the trap.

	♂	♀	% ♀		♂	♀	% ♀
♂♂ only				♀♀ 20–46%			
M. dentina	20	0	0	*A. lychnidis*	673	200	23
A. tragopogonis	15	0	0	*L. conigera*	90	29	24
				M. bicoloria	184	59	24
♀♀ 1–20%				*X. monoglypha*	557	183	25
H. micacea	75	1	1	*C. trapezina*	12	4	25
P. arcuosa	52	1	2	*M. strigilis*	76	26	26
R. tenebrosa	137	3	2	*L. lithargyria*	28	10	26
T. cespitis	45	1	2	*L. pallens*	149	59	28
A. lunosa	560	14	2	*N. c-nigrum*	414	175	30
N. primulae	103	3	3	*A. gemina*	11	5	31
C. matura	194	6	3	*H. serena*	10	6	36
M. fasciuncula	166	7	4	*P. meticulosa*	12	7	37
H. nictitans	26	1	4	*A. secalis*	186	110	37
L. comma	88	4	4	*A. puta*	35	22	40
C. trigrammica	79	5	5	*O. vaccinii*	10	8	44
A. exclamationis	2191	146	6	*O. spadicea*	8	7	46
N. rubi	230	21	8				
N. umbrosa	22	2	8	Equality of sexes			
E. adusta	12	1	8	*N. plecta*	7	7	50
N. xanthographa	593	56	9	*D. carpophaga*	10	10	50
L. testacea	552	52	9	*P. gamma*	27	27	50
N. augur	18	2	10				
C. graminis	32	4	11	♀♀ in excess			
A. luctuosa	21	3	12	*A. basilinea*	7	10	59
N. persicariae	42	6	12	*X. lithoxylea*	9	32	78
L. impura	195	29	13	*M. gilvago*	4	19	83
E. popularis	269	46	14				
T. pronuba	46	8	15				
T. gothica	117	22	16				
H. sordida	22	4	16				
T. incerta	10	2	17				

It will be seen that in nearly all the species more males were captured than females. In only two species, *M. dentina* and *A. tragopogonis*, were no females seen and in neither case were the total captures high.

In twenty-seven species the proportion of males to females was 4 : 1 or over, including several species which were quite abundant, such as *A. exclamationis* of which over 2000 individuals were caught with only 6% females, and *L. testacea* of which there were over 600 individuals with 10% females.

In another sixteen species the males outnumbered the females, but not to the same extent (females 20–46% of the total), including *X. monoglypha* with over 700 and *A. lychnidis* with over 800 individuals, with 25 and 23% females.

In *N. plecta*, *P. gamma* and *D. carpophaga* there was an equal number of males and females.

Finally there are three species only in which the females outnumbered the males : *A. basilinea*, in which the number of females is only just above the number of males and probably not significantly so; and *X. lithoxylea* and *M. gilvago*, in each of which quite a definite excess of females was captured.

There appears to be no rule with regard to any genus, and species of the same genus may be high or low in the list.

Table 18 shows the sex proportions during 1933–36 of species of other families of Lepidoptera. In the Bombyces (s.l.) seven out of thirteen species gave no females and the highest proportion was 19% in *Cilix glaucata*.

TABLE 18.

Sex ratio of species of Lepidoptera (other than NOCTUIDAE) which were sexed in all four years.

	♂	♀	% ♀		♂	♀	% ♀
Bombyces (s.l.)				LITHOSIIDAE			
P. tremula .	19	0	0	*L. lurideola* .	232	1	0·4
P. bucephala .	37	0	0	HEPIALIDAE			
M. neustria .	113	0	0	*H. lupulinus* .	126	25	17
C. potatoria .	28	0	0	*H. sylvina* .	48	24	33
N. cuculatella .	15	0	0	*H. humuli* .	0	3	100
S. mendica .	36	0	0	GEOMETRIDAE			
A. caja . .	28	0	0	*A. betularia* .	20	0	0
P. similis . .	110	2	2	*E. alniaria* .	26	0	0
S. menthastri .	202	9	4	*C. elinguaria* .	44	1	2
P. populi . .	64	4	6	*E. fuscantaria* .	39	2	5
H. derasa . .	21	2	9	*C. ferrugata* .	114	16	12
S. lubricipeda .	108	12	10	*O. luteolata* .	27	4	13
C. glaucata .	22	5	19	*C. unidentaria* .	179	68	28

In the LITHOSIIDAE the only species that came in any numbers gave only one female out of 232 captured.

In the HEPIALIDAE, on the contrary, *H. lupulinus* had 17% females, *H. sylvinus* 33%, while in *H. humuli* the only three captured were all females.

In the GEOMETRIDAE only a few species were sexed in the first three summers; the results for these in all years are shown in Table 18. The highest percentage of females was 28% in *C. unidentaria*.

During 1936 all the GEOMETRIDAE were sexed and gave a total of 238 males and 66 females, or 21·7% females, up to the end of October. The information on the species which came in any numbers (apart from those in Table 18) is

shown in Table 19. It will be seen that females were unusually abundant in *M. fluctuata* and in some species of the genus *Eupithecia*.

The other groups of Lepidoptera were not sexed until 1936 and the results are in Table 19. In the PYRALIDIDAE females outnumbered the males in *P. costalis*, *A. sociella* and in unidentified species of the genus *Scoparia*.

TABLE 19.

Sex ratio of species of Lepidoptera which were sexed in 1936 only.

	♂	♀		♂	♀
GEOMETRIDAE			PYRALIDAE		
M. fluctuata	15	21	*P. forficalis*	35	4
O. luteolata	16	4	*E. urticalis*	7	1
A. aversata	11	1	*P. costalis*	11	27
Eupithecia spp.	0	6	*S. verticalis*	4	3
E. oblongata	2	2	*A. sociella*	0	4
E. venosata	2	0	*S. olivalis*	4	1
E. subfulvata	3	10	*Scoparia* spp.	27	54
H. furcata	4	7	*B. ruralis*	17	9
C. pyraliata	11	0	PTEROPHORIDAE		
A. grossulariata	18	0	*A. pentadactyla*	2	3
P. pruinata	9	2	*P. monodactylus*	3	2
C. elinguaria	13	0	*P. gonodactylus*	12	1
T. amata	10	1	TORTRICIDAE		
O. dilutata	17	0	*E. hamana*	14	0
CRAMBIDAE			*O. striana*	75	0
C. tristellus	626	12	*S. roborana*	26	2
C. perlellus	277	25	*E. dubitana*	130	8
TINEIDAE					
P. maculipennis	302	46			
C. quercana	8	2			

In the PTEROPHORIDAE, in small total numbers, both sexes were in more or less equal numbers in two species and males in excess in one species.

In the CRAMBIDAE the females were less than 2% in *C. tristellus* and just under 10% in *C. perlellus*.

In the TORTRICIDAE the females were always in small numbers. While in *P. maculipennis* of the TINEIDAE there were about 13% females in quite large catches.

So it may be seen that in the Lepidoptera there is strong evidence that a light trap attracts more males than females in nearly all species; but that the actual percentage is very different in different species, and that there are a few exceptional cases in which more females than males are caught.

Diptera.

Among the large number of Diptera captured it has only been possible to make any extended study of the sex proportions in the family TIPULIDAE. The figures for the TIPULINAE for 1933 and 1934 have already been published (Pinchin and Anderson 1936); the figures for 1935 and 1936 have been prepared by A. G. Robertson. The figures for the LIMNOBIINAE and the TRICHOCERINAE were worked out by R .D. Pinchin from March 1933 to February of 1934, but have not previously been published. The results for 1935 and 1936 have been worked out by Mr. A. G. Robertson. Table 20 gives a summary of the results.

TABLE 20.

Sex proportion in the family TIPULIDAE (Diptera).

♂♂ in excess	♂	♀	% ♀	♀♀ in excess	♂	♀	% ♀
TIPULINAE (1933–36)				TIPULINAE (1933–36)			
Pales maculata	247	12	4·6	*Tipula obsoleta*	136	352	72·1
P. flavescens	196	33	14·4	*T. oleracea*	29	84	74·3
Tipula paludosa	1388	561	28·8	*T. marmorata*	16	111	87·4
T. pagana[a]	194	0	—				
LIMNOBIINAE (1933–34)				LIMNOBIINAE (1933–34)			
Dicranomyia modesta	10	0	0	*Rhipidia maculata*	11	53	82·8
D. sericata	19	17	47·2	*Dicranomyia chorea*	8	48	85·7
Eriopiera taenionota	42	31	42·5	*Molophilus bifilatus*	8	33	80·5
Cheilotrichia imbuta	45	23	33·8	*Symplectomorpha stictica*	54	62	53·5
Gonomyia tenella	15	5	25·0	*Empeda nubila*	39	571	93·6
Empeda flava	10	1	9·1	*Trimicra pilipes*	21	26	55·3
				Crypteria limnophiloides	3	23	88·5
				Limnophila ochracea	4	7	63·6
TRICHOCERINAE (1933–34)				TRICHOCERINAE (1933–34)			
Trichocera regelationis	1440	1134	44·1	*Trichocera saltator*	2302	5119	70·0
T. hiemalis	452	105	18·9	*T. annulata*	450	1717	60·6

[a] Females wingless.

It will be seen that the percentage of females captured varies from 0% in *Tipula pagana* (in which, however, the female is wingless, so no other result could be expected) and in *Dicranomyia modesta* to 93·6% in *Empeda nubila*. All three subfamilies contain species with excess either of males or of females and many genera contain species of both types. Indeed in the two closely related species *Tipula paludosa* and *Tipula oleracea*, which were at one time confused as a single species, the former has 28·8% females, and in the latter 25·7% males.

F. W. Edwards (1938) has made an examination of the MYCETOPHILIDAE caught in the trap during 1936 and he finds that there are more males than females in *Platyura lundstromi* (CERATOPLATINAE) and in *Paratinia sciarina* (SCIOPHILINAE); but that the females greatly outnumber the males in *Sciara varians* and *S. pullula* and to a lesser extent in *S. brunnipes* (SCIARINAE).

Psocoptera.

The Psocoptera captured in the trap in the autumn of 1932, before the trap was in regular use, were identified by Mr. J. V. Pearman and are shown in Table 21. One species has an excess of males, the others uncertain.

TABLE 21.

Sex proportions in Psocoptera, Neuroptera and Trichoptera.

	♂	♀		♂	♀
Psocoptera			HEMEROBIIDAE		
Peripsocus phaeoptera	21	1	*Micromus variegatus*	0	1
P. pedicularia	0	2	*Eumicromus paganus*	0	1
Elipsocus westwoodi	1	1	*Hemerobius humulinus*	0	1
Caecilius burmeisteri	1	0	*Boriomyia subnebulosa*	6	18
CHRYSOPIDAE			*Sympherobius pygmaeus*	2	14
Chrysopa carnea	5	13	*S. elegans*	1	0
C. albolineata	3	9	All HEMEROBIIDAE	9	35
C. flavifrons	1	2	Trichoptera		
C. ventralis prasina	1	5	*Hydropsyche pellucidula*	10	1
C. phyllochroma	1	0	*H. instabilis*	1	2
All CHRYSOPIDAE	11	29	*Limnophilus limatus*	7	2

Neuroptera.

The CHRYSOPIDAE and HEMEROBIIDAE captured in the trap in 1932, 1933 and 1934 were identified by Dr. F. J. Killington (Williams and Killington 1935). The species and sex proportions are shown in Table 21. In both families and in all species except two (in each of which only a single male was captured) there is an excess of females in the light trap.

Heteroptera.

Mr. D. C. Thomas, who has studied the Heteroptera captured in the light trap (Thomas 1938), has given me a summary of the sex of captures during 1933, 1934 and 1935, shown in Table 22.

TABLE 22.

Sex proportion in Heteroptera.

	♂	♀	% ♀
PENTATOMIDAE (1 species) . .	0	1	(100)
LYGAEIDAE (2 species) . .	0	2	(100)
NABIDIDAE (3 species) . .	3	13	81
ANTHOCORIDAE (2 species) . .	6	0	0
CAPSIDAE (54 species) . .	1181	85	7
CORIXIDAE (6 species) . .	8	34	81

Females are in excess in the NABIDIDAE and the CORIXIDAE; males are in excess in the ANTHOCORIDAE and in the CAPSIDAE. In the latter family females appeared in only 16 species out of the 54 captured, and were in excess only in three species, in each of which only one or two individuals were captured. The family characteristics appear to be more strongly marked than usual in this order of insects.

Trichoptera.

A small number of Caddis-flies captured in the trap in 1932 were identified by Dr. F. J. Killington as shown in Table 21. In the two more abundant species there was in each case an excess of males.

Factors Affecting the Sex Proportion.

Variations in Sex-ratio in Different Years.

A comparison of the sex proportion in the family NOCTUIDAE of the Lepidoptera in the four years under discussion is shown in Table 23.

TABLE 23.

Sex proportion in NOCTUIDAE in each of the four years.

	1933	1934	1935	1936
Total males . . .	1230	1517	4666	1085
Total females . . .	233	339	794	198
Per cent. females . .	16	18	15	15

From this it would appear that there is no very great variation in sex proportion from year to year in the groups as a whole. These figures cannot, however be taken further without comment as in 1935 the species *Agrotis exclamationis* was very abundant and made up over one-third of the total capture; and being a species with less than 6% females it unduly weights the year's total. Without this species the proportion of females in 1935 is 24%.

Although no indication of variation can be obtained from the total figures there are some striking cases of variation in different species as shown in Table 24.

TABLE 24.

Varying sex proportion in different years in certain species of NOCTUIDAE.

	1932		1933		1934		1935		1936	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
A. secalis .	—	—	15	13	5	20	154	69	10	7
X. lithoxylea .	—	—	6	2	0	18	2	7	1	5
A. puta .	—	—	1	0	5	10	27	12	2	0
M. persicariae	—	—	7	0	12	0	22	6	1	0
E. popularis .	12	0	32	0	96	13	104	28	25	5
T. gothica .	—	—	48	6	34	14	32	2	10	3

Apamea secalis had almost an equality of sexes in 1933 and 1936, the females much outnumber the males in 1934 and the reverse is the case (in quite large numbers) in 1935.

X. lithoxylea produced more males than females in 1933, not a single male in 1934 and more females than males in 1935 and 1936.

A. puta gave more females than males in 1934 and the reverse in 1935. *M. persicariae* gave no females in either 1933 or 1934 but about 25% in 1935, while *E. popularis* was somewhat similar, giving no females in either 1932 or 1933 but quite a distinct percentage in 1934 and 1935.

T. gothica gave only 6% females in 1935, 29% in 1934, and in intermediate value about 11% in 1933.

No significant difference has been noted in the sex proportion in different years in the other groups investigated, with the exception of *Tipula paludosa*, which gave 27% of females in 1933; 18% in 1934; 27% in 1935, and 49% in 1936.

Variation of Sex Proportion in Different Broods.

About twenty double brooded species of Lepidoptera were captured in the trap, but of these some were not sexed, others had few or no females and in still others one of the broods was represented only by very few individuals.

Table 25 shows the sex proportion in three species of NOCTUIDAE and two of GEOMETRIDAE which remained after the above had been eliminated. The figures for the NOCTUIDAE are for 1933–35, the figures for the GEOMETRIDAE for 1933 and 1934 only.

It will be seen that there are some distinct differences in the sex ratio in the broods, but that they are not consistent in all species. *N. rubi* shows a lower proportion of females in the second brood, while in *L. pallens* and both Geometrids the proportion is higher. In *N. c-nigrum* there is no significant difference.

TABLE 25.

Sex proportion in different broods of certain Lepidoptera.

	First brood.			Second brood.		
	♂	♀	%♀	♂	♀	%♀
NOCTUIDAE						
N. rubi	42	8	16	146	13	8
L. pallens . . .	57	11	16	84	39	32
N. c-nigrum . . .	16	8	33	305	121	28
GEOMETRIDAE						
C. unidentaria . . .	40	8	17	119	54	31
C. ferrugata . . .	31	2	6	75	13	15

Variation of Sex Proportion at Different Times During a Single Brood.

It has been found, in most species of NOCTUIDAE in which females come in any numbers, that the females tend to appear in the trap some days later than the males, and so form a larger proportion of the catch later in the brood than earlier. To demonstrate this, the date of first appearance of the males and females in several species has been tabulated, and also the date at which half the total captured males and half the total females have appeared. Since the males are generally more numerous in the trap than the females, one would expect by chance that the first males would appear before the first females, but a difference in the date when half the numbers have been captured should indicate a real difference.

Table 26 shows the results in seven species of NOCTUIDAE in which a sufficient number of both sexes were captured in all three years. It shows that in

TABLE 26.

Dates of appearance of males and females during the broods in certain NOCTUIDAE.

Species	Year	Total captures		First capture		♀♀ later in days	Half capture		♀♀ later in days	Average difference of three years	
		♂	♀	♂	♀		♂	♀		1st ♀	half-brood
A. exclamationis	1933	94	5	5 June	7 June	2	19 June	15 June	−3		
	1934	142	23	1 ,,	16 ,,	15	26 ,,	22 ,,	−4	8	−2
	1935	1697	102	13 ,,	20 ,,	7	3 July	4 July	1		
X. monoglypha	1933	19	8	25 June	29 June	4	22 July	18 July	−4		
	1934	69	21	14 ,,	26 ,,	12	8 ,,	11 ,,	3	5	2
	1935	457	146	25 ,,	24 ,,	−1	22 ,,	28 ,,	6		
A. secalis	1933	15	13	6 July	14 July	8	21 July	23 July	2		
	1934	5	20	15 ,,	19 ,,	4	16 ,,	30 ,,	14	7	6
	1935	154	69	11 ,,	21 ,,	10	31 ,,	3 Aug.	3		
N. xanthographa	1933	174	15	6 Aug.	15 Aug.	11	25 Aug.	29 Aug.	4		
	1934	94	6	6 ,,	18 ,,	12	22 ,,	24 ,,	2	6	3
	1935	155	17	5 ,,	1 ,,	−4	25 ,,	28 ,,	3		
N. c-nigrum	1933	32	23	10 Aug.	18 Aug.	8	24 Aug.	31 Aug.	7		
(2nd brood)	1934	60	21	16 ,,	16 ,,	0	5 Sept.	12 Sept.	7	6	5
	1935	220	80	8 ,,	19 ,,	9	30 Aug.	30 Aug.	0		
L. pallens	1933	65	17	23 Aug.	26 Aug.	3	30 Aug.	30 Aug.	0		
(2nd brood)	1934	15	14	21 ,,	22 ,,	1	6 Sept.	12 Sept.	6	3	2
	1935	4	8	5 Sept.	9 Sept.	4	9 ,,	9 ,,	0		
A. lychnidis	1933	273	51	12 Sept.	22 Sept.	10	22 Sept.	2 Oct.	7		
	1934	160	59	12 ,,	14 ,,	2	1 Oct.	2 ,,	1	4	3
	1935	157	75	21 ,,	20 ,,	−1	2 ,,	4 ,,	2		
						Average days later for all species				5·6	2·6

all species, on an average of three years, the first male appears before the first female, with a mean difference of 5–6 days, the only three exceptions being in single species in single years. In the case of the date of appearance of half the total the females are later than the males in six out of the seven species by a mean of 2·6 days. *A. exclamationis* gives a reverse result in two years and *X. monoglypha* in one.

Therefore it seems to be a general rule in the NOCTUIDAE that the females are captured in the trap in a higher proportion in the second half of the brood than in the first.

Among the Diptera *Trichocera saltator* (TIPULIDAE) showed an interesting series of captures in 1933–34 as shown in Table 27. When the captures started in October 1933 there were only 33% females but by December 1933 to February 1934 the percentage had risen to about 75%. This species was not sorted

TABLE 27.

Sex proportion in *Trichocera saltator* (Diptera, TIPULIDAE) in successive months throughout the winter.

		♂	♀	% ♀
1933	October . . .	860	417	33
	November . . .	479	417	47
	December . . .	13	45	76
1934	January . . .	5	17	77
	February . . .	12	28	70
(1933)	March	53	75	59
	April	16	111	87
	May	0	19	100

out after this date, but if one takes the previous spring as a normal continuation, one has evidence that the increase in the proportion of females continues until by May there are no males in the catch. This might be explained by the gradual death of the males while many females survive the winter.

Differences in Sex Proportion at Different Times of the Night.

Table 28 shows the number of both sexes and the proportion of females captured in the trap before and after midnight in various Lepidoptera, Diptera and Neuroptera.

It will be seen that in the NOCTUIDAE seven out of the nine species discussed show a larger proportion of females in the first half of the night. *Noctua c-nigrum* is the only species to show a significant reverse effect and there is one other in which there is no apparent difference.

Both species of GEOMETRIDAE resemble the majority of NOCTUIDAE and show a larger proportion of females before midnight.

In the Diptera only the TIPULIDAE have been studied from this point of view. The results are quite conflicting even within the same genus and species. Both *Tipula paludosa* and *T. oleracea* show one year with the proportion of females higher before midnight and one the opposite way. In the genus *Trichocera* (only identified during one year) two species show a higher proportion of females before midnight, one after midnight and one with no difference.

In the Neuroptera, both HEMEROBIIDAE and CHRYSOPIDAE show a higher proportion of females before midnight.

TABLE 28.

Difference in sex proportion in captures before and after midnight in certain Lepidoptera, Diptera and Neuroptera.

	Years	Before midnight		After midnight		Per cent ♀♀	
		♂♂	♀♀	♂♂	♀♀	Before	After
Lepidoptera							
NOCTUIDAE							
Amathes lychnidis	1933–34–35	254	98	249	49	**27·8**	16·4
Agrotis exclamationis	,,	503	47	1290	81	**8·5**	6·0
Xylophasia monoglypha	,,	143	76	360	81	**34·7**	18·4
Noctua c-nigrum	,,	185	59	120	57	24·2	**32·2**
Leucania pallens	,,	54	24	58	17	**30·8**	22·7
Noctua xanthographa	,,	346	30	76	7	8·0	8·4
Apamea secalis	,,	51	63	83	27	**55·3**	24·5
Luperina testacea	1933–36	170	45	346	5	**20·9**	1·4
Plusia gamma	,,	5	14	14	6	**73·7**	30·0
GEOMETRIDAE							
Coremia ferrugata	1933–34	67	12	39	3	**15·1**	7·1
C. unidentaria	,,	91	51	68	11	**35·9**	14·0
DIPTERA							
Tipula obsoleta	1933	18	33	13	93	65	**88**
,,	1934	10	75	6	29	**88**	83
T. paludosa	1933	215	87	219	46	**28·5**	17·3
,,	1934	165	52	129	5	24	**37**
Trichocera regelationis	1933	863	567	532	505	39·6	**48·7**
Trichocera annulata	,,	102	528	343	1271	**83·8**	78·8
T. hyemalis	,,	153	38	265	64	19·9	19·4
T. saltator	,,	835	1839	1185	3033	**68·8**	62·3
Neuroptera							
All HEMEROBIIDAE	1933–34	5	20	4	5	**80·0**	55·5
All CHRYSOPIDAE	,,	3	9	8	20	**75·0**	71·4

Variation in Sex Proportion at Different Levels above the Ground.

The trap from which all the above results have been obtained has been exposed in a field at Rothamsted with the light, as has been explained, about 3 feet 6 inches (106 cm.) above the level of the ground.

In August 1933 a second trap was made of very similar construction (except that it was round instead of square and had no bottle-changing mechanism) and with the same power of illuminant. It was placed on one corner of the flat roof of the Entomological Laboratory at a height of about 35 feet (10·6 metres) from the ground and overlooking on two sides gardens and allotments. The horizontal distance between the two traps was about 350 yards.

In the period from 8th August to 31st October 1933 the lower trap (A) captured 930 NOCTUIDAE, while the upper trap (B) captured 1775. In the lower trap there were 138 females (14·8%) and in the upper trap 455 females or 25·7% (Table 29).

To check this unexpectedly high proportion of females in the upper trap, it was again put out in the same situation during August 1934 and caught 401 NOCTUIDAE with 27% females, while the lower trap caught 310 NOCTUIDAE with only 8·9% females.

This difference in the percentage of females in the two traps might be explained by

(*a*) Some difference in the construction and efficiency of the traps;
(*b*) Some difference in the outlook of the traps, *i.e.* in the ecological association from which they drew their catch;

or

(*c*) A tendency for females to fly in greater proportion, relative to the number of males, at higher levels.

To test the first, trap B was during September 1934 brought down to the lower level in a situation about 200 yards from trap A with a very similar outlook. The proportion of females in the two traps and the total catches were practically the same; 350 males and 85 females (19% females) in trap A (not moved) and 368 males and 77 females (17% females) in trap B.

TABLE 29.

Sex proportion of NOCTUIDAE captured in traps at two different levels above the ground.

		Trap A : 3 feet 6 inches above ground			Trap B : 35 feet above ground		
		♂♂	♀♀	% ♀	♂♂	♀♀	% ♀
1933	8.viii. to 1.xi. . .	792	138	14·8	1320	455	25·7
1934	August . . .	283	27	8·9	292	109	27·0
1935	May . . .	33	2	7	15	1	7
1934	June . . .	731	35	5	84	14	14
	July . . .	2267	330	7	267	71	21
	August . . .	1000	252	20	150	50	25
	September . .	572	72	12	27	13	33
	October . . .	104	52	33	12	18	60
1935	Total . . .	4707	743	13·6	555	167	23·1
1936	May . . .	6	3	—	6	1	—
	June . . .	256	16	59	148	36	19·6
All years		6044	927	13·3	2321	768	24·9

In 1935 trap B was mounted on a tripod (Plate 1) immediately above trap A so that it had the same outlook, but a height of 35 feet, equal to that of the original site on the roof of the laboratory. The catch of NOCTUIDAE during the six months May to October 1935 in each trap is shown in Table 29.

In May the proportion of the sexes in each trap was the same but on very small total numbers. In each of the five months after this the percentage of females in the upper trap exceeded that in the lower trap, and in the month of October there were actually more females than males in the upper trap.

Still further confirmation was obtained by a continuation of a similar experiment in May and June 1936, when the upper trap had again a much higher percentage of females in June, though in May the result was reversed with a very small number of insects. In 1936 there was a slight difference in the arrangement of the experiment. Instead of both traps being lit each night, the nights were divided into successive groups of three, and in each group there was one night with the upper trap only lit, one with the lower trap only, and one with both traps. This made no apparent difference to the result.

The upper trap caught nearly twice as many NOCTUIDAE as the lower when it was on the roof of the building (1675 : 930), but only about one-sixth the number when on the tripod (913 : 5731).

Throughout the whole series of experiments the captures in the lower trap included 13·3% females, and the captures at a height of 35 feet included 24·9% females or practically double the percentage.

The above results show the difference in percentage of females when all NOCTUIDAE are considered together. When the species are separated it is found that the difference is more strongly marked in some species than in others.

A comparison of the sex proportions in different species caught over the same period in 1933 and 1934 is shown in Table 30. These were all autumn (August–September–October) catches.

TABLE 30.

Sex proportion in different species of NOCTUIDAE caught in traps at different levels in 1933 and 1934.

Species	A on ground		B on roof	
	♂	♀	♂	♀
More ♀♀ in lower trap				
M. brassicae	0	3	29	33
A. secalis	0	4	2	2
M. gilvago	0	8	13	9
Similar proportions				
N. c-nigrum	90	30	316	85
L. testacea	152	4	42	3
A. lunosa	52	5	23	2
A. lychnidis	280	51	638	195

Species	A on ground		B on roof	
	♂	♀	♂	♀
More ♀♀ in upper trap				
N. rubi	71	5	8	6
N. xanthographa	276	11	186	86
N. plecta	2	0	8	3
L. pallens	68	24	67	67
A. tragopogonis	2	0	17	7
N. populariis	72	5	2	7
A. puta	3	2	5	7

It will be seen that three species give a higher proportion of females in the lower trap, but in all these cases there were only small numbers in the lower trap. The most striking is *M. gilvago*, with 8 females and no males in the lower trap and 9 females to 13 males in the upper.

Four species, *N. c-nigrum*, *L. testacea*, *A. lunosa* and *A. lychnidis*, all of which came in fair numbers in both traps, gave more or less similar proportions in each.

Four species in fair numbers, and three others in small numbers, gave distinctly higher proportions of females in the upper trap. The most significant differences are in *N. rubi*, *N. xanthographa*, *L. pallens* and *N. populariis*.

In 1935 the upper and lower traps were running in comparison for six months, but the upper trap was suspended from the tripod and caught much fewer NOCTUIDAE than the lower trap. As a result, significant differences could only be expected in a few species. Table 31 shows the information available for this year. A number of species gave non-significant results but they are not mentioned unless they had been previously dealt with in Table 33.

A comparison of Table 30 and 31 shows the following points :—

(*a*) Of the species which gave more females in the lower trap in 1933–34 only one, *A. secalis*, occurred in both traps in 1935 and this gave again a similar result in much larger numbers. In 1935 two other species, *P. gamma* and *A. putris*, gave more females in the lower trap but in both cases in small numbers.

(*b*) The four species that gave more or less similar proportions in both traps in 1933–34 (*N. c-nigrum*, *L. testacea*, *A. lunosa* and *A. lychnidis*) all gave higher proportions of females in the upper trap in 1935.

(*c*) Of the seven species that gave a higher proportion of females in the upper trap in 1933–34 only two (*L. pallens* and *N. xanthographa*) reappeared in sufficient numbers in both traps in 1935. Both these confirmed the previous results. The most striking case was *L. pallens*, which in 1935 gave more females than males in the upper trap.

TABLE 31.

Sex proportion in different species of NOCTUIDAE caught in traps at different levels in 1935.

Comparison of sex proportion in Upper and Lower Trap, May to October, 1935.

	On ground		On tripod		% of ♀♀	
	♂	♀	♂	♀	Lower	Upper
Numbers not significant						
A. puta	2	0	4	1	—	—
A. tragopogonis	5	0	2	1	—	—
N. rubi	32	4	1	0	—	—
More ♀♀ in lower trap						
P. gamma	9	8	13	5	47·0	27·8
A. putris	3	3	4	0	50·0	0
A. secalis	154	69	49	7	30·9	12·5
Similar proportion in each trap						
T. gothica	17	0	4	0	0	0
H. sordida	13	4	4	1	23·5	20·0
L. conigera	49	15	5	2	23·4	28·6
M. bicoloria [4]	111	28	3	1	20·1	25·0
M. literosa	0	3	0	1	100	100
More ♀♀ in upper trap						
A. exclamationis	1697	102	203	34	5·7	14·3
X. monoglypha	457	146	61	28	24·2	31·5
P. meticulosa	10	6	2	4	37·5	66·6
N. c-nigrum	235	88	66	32	27·2	32·2
T. pronuba	32	2	29	7	5·9	19·4
L. pallens	29	6	9	11	17·1	55·0
N. xanthographa	155	17	12	4	9·9	25·0
A. lychnidis	157	75	17	17	32·3	50·0
L. testacea [4]	255	39	3	2	13·3	40·0
A. lunosa [4]	195	5	3	1	2·5	25·0

[4] Numbers in upper trap doubtfully significant.

(*d*) In addition to the above six species, a higher proportion of females was found in the upper trap in 1935 in *A. exclamationis*, *X. monoglypha*, *P. meticulosa* and *T. pronuba*.

Thus the species with a higher proportion of females in the upper trap include all those that came in significant numbers, with the exception of *A. secalis* and *M. gilvago*.

Relation of Percentage of Females to Abundance of Individuals.

An examination of the numbers of females and males of the Noctuid *Agrotis exclamationis* caught on different nights during 1935 seemed to indicate that a smaller proportion of females was caught on nights when the species was abundant. To test the truth of this the figures shown in Table 32 were prepared. In this all the catches of males and females on nights when 1–4 individuals were caught were added together and the percentage of females calculated; similarly with nights on which 5–9, 10–19, etc., were caught. The percentage of females shows a steady reduction from 29·3% when 1–4 insects were caught per

night down to 3·6% when over 100 insects were caught per night (see also fig. 3). This result cannot be tested for this species in other years as on no night during either 1933 or 1934 were more than 10 individuals captured.

Table 32 shows a similar set of figures for the Noctuid *A. lychnidis*, which came

TABLE 32.

Relation of sex proportion to abundance per night in certain species of NOCTUIDAE.

Year	Catch per night	No. of nights	Total catch.		Mean catch per night		Per cent. of ♀♀
			♂♂	♀♀	♂♂	♀♀	
			Agrotis exclamationis				
1935	1–4	16	24	10	1·5	0·6	29·3
	5–9	8	48	9	6·0	1·1	15·8
	10–19	5	57	7	11·4	1·4	10·9
	20–49	8	244	18	30·5	2·3	6·9
	50–99	9	628	32	69·8	3·5	4·9
	100 and over	4	686	26	171·5	8·5	3·6
			Amathes lychnidis				
1933	1–4	18	32	11	1·8	0·6	25·6
	5–9	9	54	10	6·0	1·1	15·6
	10 and over	7	174	31	24·9	4·4	15·1
1934	1–4	18	18	13	1·0	0·7	41·9
	5–9	11	47	26	4·3	2·4	35·6
	10 and over	7	95	18	13·6	2·6	15·9
1935	1–4	19	20	18	1·1	0·9	47·3
	5–9	7	30	16	4·3	2·3	34·8
	10 and over	6	107	41	17·8	6·8	27·7
All three years	1–4	55	70	42	1·3	0·8	37·5
	5–9	27	131	52	4·9	1·9	28·7
	10 and over	20	376	90	18·8	4·5	19·3
			Xylophasia monoglypha				
1935	1–4	26	26	15	1·0	0·6	36·6
	5–9	8	41	11	5·1	1·4	21·1
	10–19	12	117	49	9·8	4·1	29·5
	20–49	8	165	58	20·6	7·3	26·0
	50–99	0	—	—	—	—	—
	100 and over	1	112	13	112	13	10·4

in fair numbers in all three years. It was only possible to divide this species into three classes in each year, namely 1–4, 5–9 and "10 or more." In each of the three years the percentage of females is highest in the low captures and lowest in the high captures; while the average of the three years shows a steady gradation from 37·5% in nights when 1–4 were captured, to 28·7% when 5–9 were captured and to 19·3% when 10 or more were captured.

The only other moth which came in sufficiently large numbers and with a sufficiently high proportion of females was *X. monoglypha* in 1935, the tabulation of which is also shown in Table 32. It will be seen that there is again evidence of a gradual lowering in the percentage of females with increasing catch, but there is one inconsistent value (21·1% for catches of 5–9 insects) and the low value for catches of over 100 is based on a single night only.

From the above there appears to be distinct evidence that in the NOCTUIDAE which come to the light in any considerable numbers and with a fair percentage of females, there is a general rule that the females are relatively more abundant on nights with low catch than nights with a high catch (al-

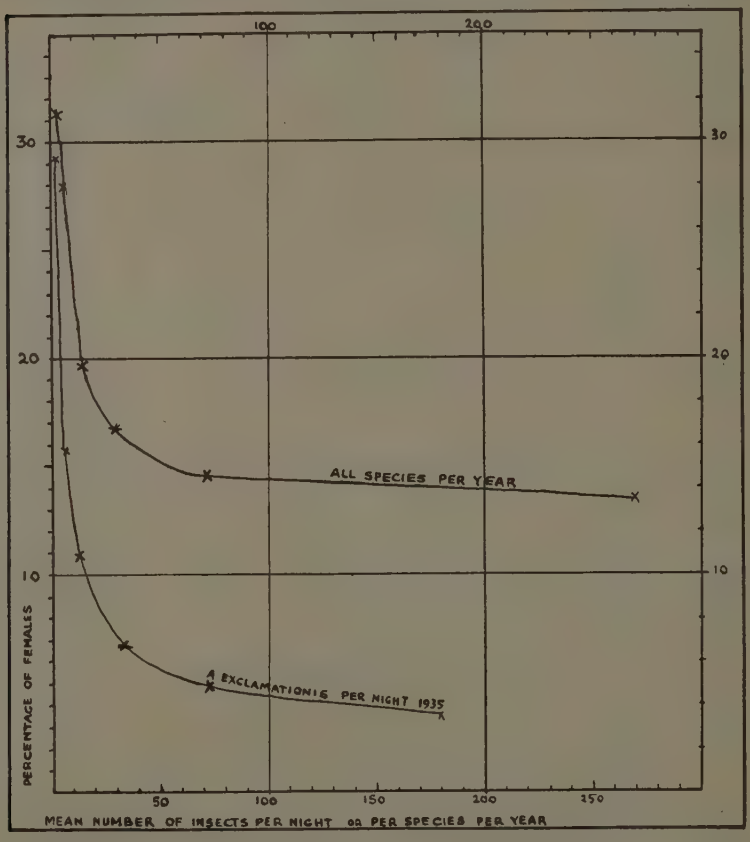

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FIG. 3.—Diagram showing relation of total abundance and sex proportion in *Agrotis exclamationis* in 1935 and in all species of Lepidoptera in all four years.

though of course they are actually in greater numbers on the nights with high catch).

Since it has been shown above that in most species the males come to the trap for several days before the females appear, it might be argued that these days should be eliminated from discussion of any factor affecting the proportion of females and males. If this were done the percentage of females on nights

with small catch, on days only after the females had started to appear, would be even larger than those obtained above.

The problem of the relation of the proportion of females to abundance can be studied also from the point of view of the total abundance of a species during the year. Table 33 shows the number of individuals of each sex caught per year in the species of NOCTUIDAE classified according to the total numbers of each species caught during that year.

TABLE 33.

Relation between sex proportion and total abundance per year in species of NOCTUIDAE.

	Numbers per year					
	1–4	5–9	10–19	20–49	50–99	100 and over
1933						
Spp. . .	42	10	5	10	6	2
♂♂ . .	59	54	60	244	357	448
♀♀ . .	25	19	4	44	72	69
% ♀♀ . .	30	26	6	15	17	13
1934						
Spp. . .	30	9	9	10	5	6
♂♂ . .	45	44	87	218	333	790
♀♀ . .	24	24	44	53	76	115
% ♀♀ . .	35	35	34	20	19	13
1935						
Spp. . .	37	18	6	12	8	11
♂♂ . .	43	90	80	324	481	3683
♀♀ . .	24	27	15	57	42	624
% ♀♀ . .	36	23	16	15	8	14
1936						
Spp. . .	39	7	9	8	2	5
♂♂ . .	51	28	100	196	107	669
♀♀ . .	17	14	17	39	26	69
% ♀♀ . .	25	33	15	17	20	9
All four years						
♂♂ . .	198	216	327	982	1278	5590
♀♀ . .	90	84	80	193	216	877
% ♀♀ . .	**31·3**	**28·0**	**19·6**	**16·6**	**14·5**	**13·5**

For example, in the year 1933 forty-two species were caught in the trap with only 1–4 individuals per species for the whole year (*i.e.* the rare species). All the individuals of these species added together included 59 males and 25 females or 30% females. In the same year two species came with over 100 individuals each and the total captures for these was 448 males and 69 females or only 13% females.

There are a few inconsistent results in individual years but in the last division which shows the total for all four years, there is not a single value out of sequence (see fig. 5). In all species of which 1–4 individuals were obtained there were 31·3% females; with 5–9 individuals per species per year there are 28% females; with 10–19 individuals there are 19·6% females; with 20–49 individuals 16·6% females; with 50–99 individuals 14·5% females; and finally with 100 or more individuals per species per year there are only 13·5% females.

It would appear, therefore, that in the species that are rare throughout the

year a larger percentage of females is caught by the trap (on an average) than in the species that are common, and further that with the common species the females are in smaller proportions on nights when they are common than when they are themselves rare.

These results could be explained (or perhaps rather re-stated) by saying that the females of the NOCTUIDAE are less sensitive to conditions affecting the catch than are the males (statistically they would have a lower regression). Thus in the case of *A. exclamationis* the conditions that have provided the change from 1·5 males per night on poor nights to 171·5 males per night on good nights (an increase of 114 times) have only produced a change from 0·6 females to 8·5 females (or 14·2 times). Taking the total annual catch of the rare and common species, there is an increase of from 1·3 to 233 males per species (179 times) accompanied by an increase in the females per species of 0·6 to 37 (62 times).

The curious result is that on a very good night common species would be in high numbers and hence with a low percentage of females caught, while the few rarities which come in on such nights would still have a high proportion of females.

It would appear that with the commoner species the trap draws the males from a much larger area than the females on a night of high activity, possibly owing to the females being engaged on egg-laying. But it is difficult to explain why on this reasoning the rare species should have a high proportion of females on the same night.

It must be clearly understood that the effect discussed is entirely one of trapping. There is no evidence to suppose that any real change of sex proportion takes place in the population, except perhaps that due to an earlier emergence of males in the brood and a longer life for the females.

SOME PHENOLOGICAL PROBLEMS.

Records obtained from the trap can be used to throw light on a number of problems connected with the dates of appearance of species, the sequence of broods, and other similar phenological problems.

Fig. 4 shows, for example, the days in each of the four years when twenty-five of the commoner species of Lepidoptera have been captured in the trap. The species are arranged in order of mean date of first appearance.

It will be seen that the first species considered, *S. bilunaria*, is double brooded; that the first brood in April and May is less abundant than the second in July and August, and that no specimens of the first brood were captured in 1935 and 1936. The injurious Diamond-Back Moth (*P. maculipennis*), which is the second on the list, has been captured over a period of eight months, but shows no definite break into broods from this data. *M. fluctuata* has been caught in five months but again with no definite break between broods. *S. menthastri* is single brooded; *O. luteolata* is rather indefinitely, and *P. forficalis* quite definitely double brooded.

M. fasciuncula and *C. fulvata* are noticeable for the very short duration of the brood. *C. tristellus*, on the contrary, has a very long brood. *P. similis* produced a second brood in 1936 only, at the end of September. *H. micacea* appears in small numbers but over a long period. *E. popularis* and *A. lunosa* have rather short broods, while *A. lychnidis* is much longer.

Fig. 5 shows the mean date of first appearance of 30 species of Lepidoptera, arranged in sequence of that date and shows in addition how in each year the dates differed from the four-year mean. From this it will be seen that 1933

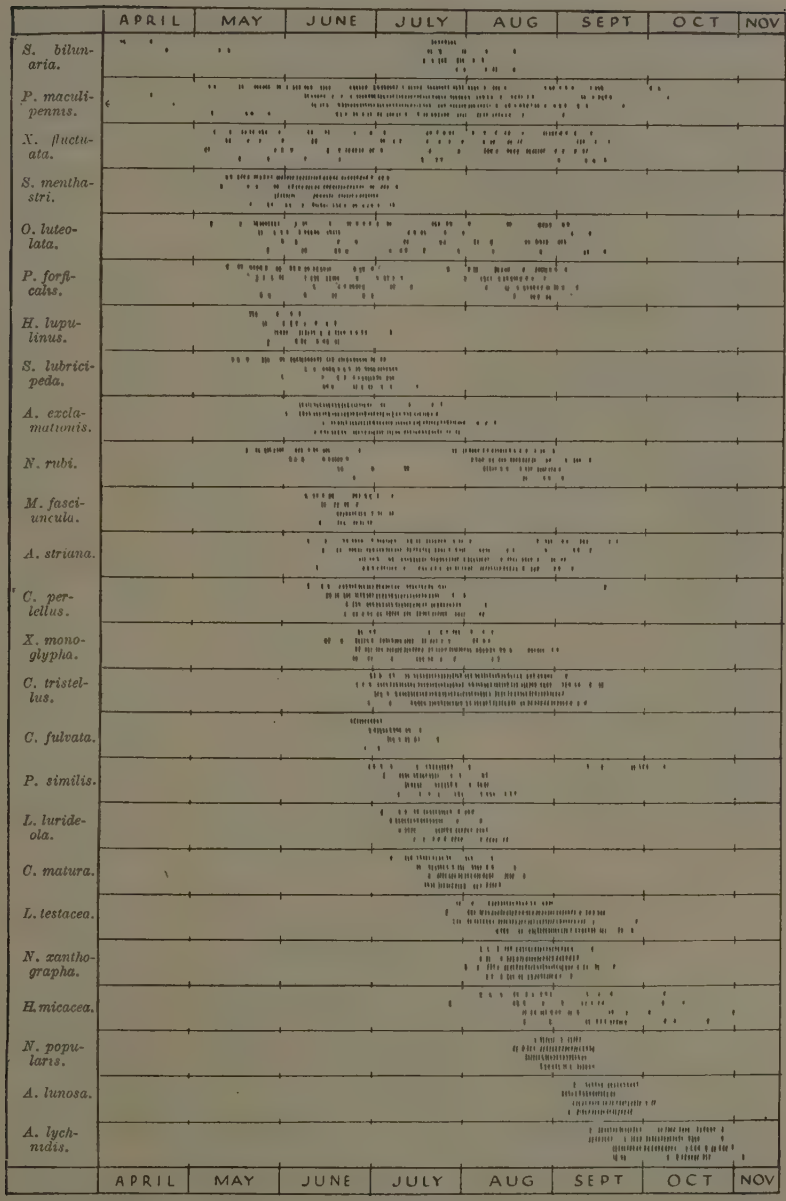

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FIG. 4.—Dates of occurrence in each of the four years of thirty species of Lepidoptera.

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was an "early year." The species in succession were gradually more early until *R. tenebrosa* which was 19 days before normal. Then there was a check, but earliness again steadily increased till *N. roborana* was 13 days early. Then, about the middle of June, another more severe check is apparent, but earliness soon reappeared with *A. grossulariata* 24 days earlier than the mean value (it actually appeared *before* the mid-June check). In the autumn conditions were much nearer normal.

In 1934 first appearances were nearer normal with, however, slight earliness at the end of June and more definite earliness in the autumn.

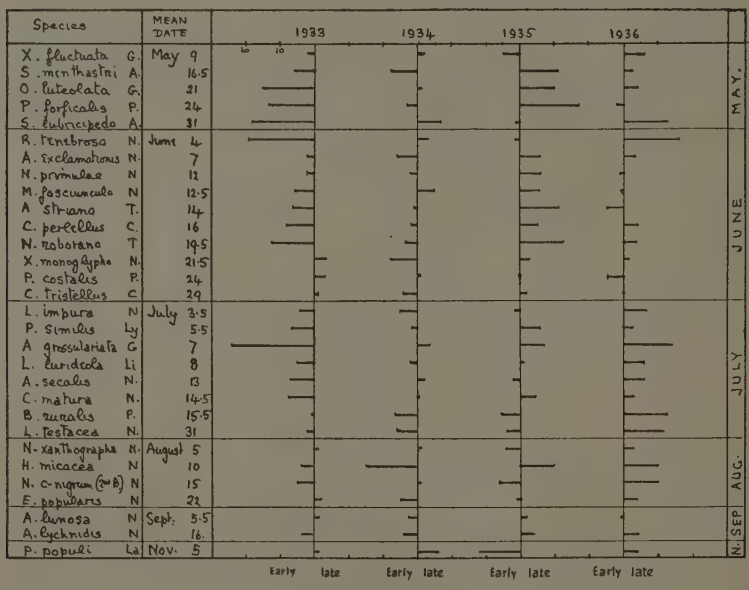

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FIG. 5.—Mean dates of first appearance and departures from the normal in each year of various species of Lepidoptera.

In 1935 species were late in appearing, especially in the second half of May and during June and July. Extremely cold weather with frosts, hail and snow was experienced in the middle of May after the first few days of the month had been abnormally warm.

In 1936 conditions were more regularly late than in 1935 and only three species showed any significant earliness. Species emerging during July and August were nearly all 5–15 days late.

Table 34 shows the mean date of first appearance of twenty-eight species of Lepidoptera which showed definite broods; the departure from the mean in each of the four years; the variability of the data as shown by the sum of the squares of the departures; the standard deviation $\left(\sqrt{\frac{\Sigma d^2}{n-1}}\right.$, where n is the

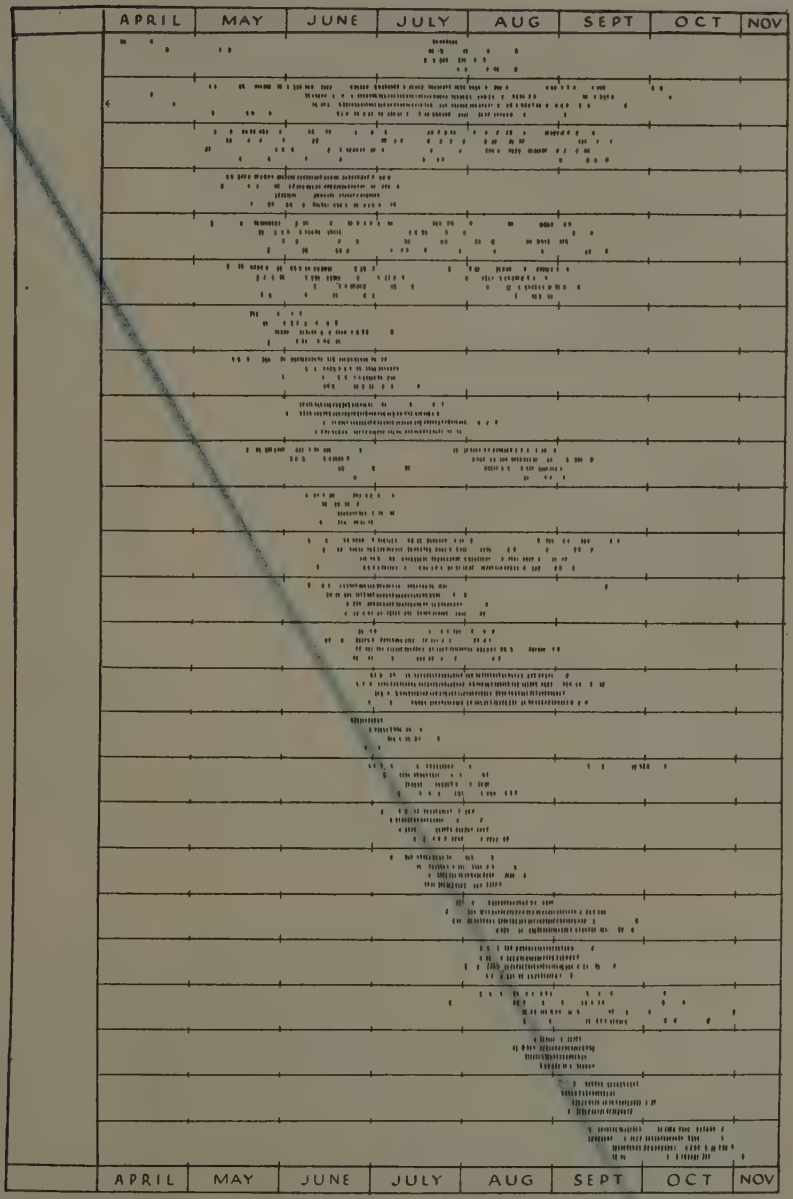

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FIG. 4.—Dates of occurrence in each of the four years of thirty species of Lepidoptera.

The average probable error of the mean is ± 4 days. In the list of twenty-eight species there are fifteen species of the family NOCTUIDAE. The mean sum of squares for these is 139 (standard deviation 6·8), indicating a slight possibility of less variability in this family.

When the variability is averaged month by month the figures shown in Table 35 are obtained.

TABLE 35.

Variation of date of first appearance of insects in different months during the summer.

Month.	Mean sum of squares	Standard deviation
May	111	10·5
June	52	7·2
July	68	8·2
August	64	7·9
September	13	3·6

It is doubtful whether these results are significant, but it is interesting to note that they show high variability in May and indication of a second peak in

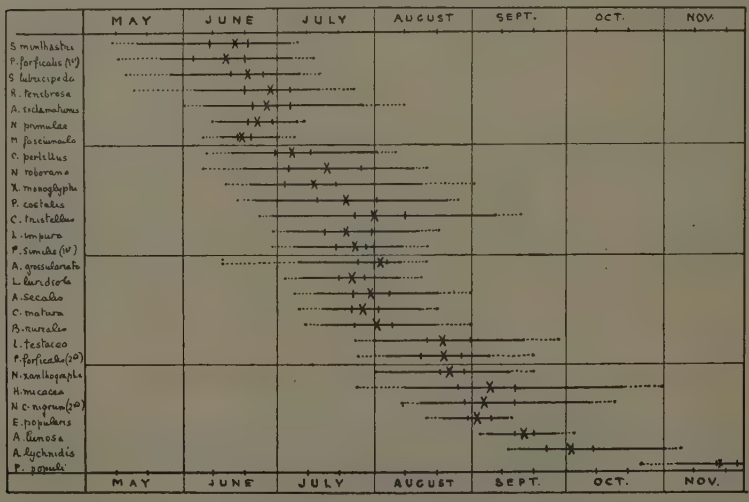

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FIG. 6.—Mean dates of certain points in the brood of some species of Lepidoptera. Dotted line to extreme first and last appearance in the four years; solid line between mean first and last appearance; cross bar at mean date of 25% and 75%; and cross at mean date of 50% appearance.

July. This is in agreement with results indicated by Gunton (1935) and worked out in more detail from his original figures. His results, based on an examination of first dates of fifty species of Lepidoptera over about 12–15 years, showed high variability in April and early May, rapidly descending to a mini-

mum in June, rising again to a maximum in late July and August and falling again in the autumn.

Further work on these lines is much needed.

In phenological work stress has been laid on the dates of first appearance of birds, flowers or insects, doubtless because this date can be most easily noted in the field.

It was decided to use the figures available from the trap records to see if the variability of the first appearance was greater or less than at other defined points in the brood.

The points chosen were the dates of the captures of 25%, 50%, 75% and 100% of all the individuals caught during that brood. The 100% figure is of course the date of the last individual of the brood.

TABLE 36.

Mean dates of certain fixed points during the brood of some species of Lepidoptera.

	Mean date of appearance: 1933–1936					Mean length of brood
	First	25%	50%	75%	Last	
S. menthastri	May 16·5	June 9	June 17	June 21	July 4·5	49
P. forficalis (1st)	24	3·5	14	20	5	43
S. lubricipeda	27	16·5	22	26	7·5	41·5
R. tenebrosa	June 4	20	28·5	July 4·5	14	40
A. exclamationis	7	22·5	27	4·5	28	51
N. primulae	12	21	24	June 29	7	25
M. fasciuncula	12·5	18	19	22	1	18·5
C. perlellus	16	30	July 5	July 11	Aug. 1	46
N. roborana	19·5	July 4	16	27	13	54·5
X. monoglypha	21·5	3	12	19	15	54·5
P. costalis	23	13	22	Aug. 1	23·5	61·5
C. tristellus	29	25	31	10	Sept. 8	71
L. impura	July 3·5	15·5	22	July 30·5	Aug. 13·5	41
P. similis (1st)	5·5	19	25	28·5	9	34·5
A. grossulariata	7	26	Aug. 2	Aug. 4	9	33
L. lurideola	8	20	July 24	July 28	8	31
A. secalis	13	24·5	30	Aug. 5	20·5	38·5
C. matura	14·5	24	27·5	1·5	15	31·5
B. ruralis	15·5	25	Aug. 1	6	19·5	35
L. testacea	31	Aug. 17	22	31	Sept. 17	48
P. forficalis (2nd)	Aug. 4	15	22·5	28	6	33
N. xanthographa	5	21	24	29	12	38
H. micacea	10	27	Sept. 6	Sept. 14	Oct. 18	69
N. c-nigrum	15	29	4	14	7·5	53·5
E. popularis	22	30	2	6·5	11·5	20·5
A. lunosa	Sept. 5·5	Sept. 14	17	20	Sept. 27	21·5
A. lychnidis	16	24	Oct. 2	Oct. 9	Nov. 1	46
P. populi	Nov. 5	Nov. 17	Nov. 18	Nov. 23·5	Dec. 17	43
					Mean length of brood	41·9

Table 36 shows the mean of these dates for the four years for the twenty-eight species, together with the mean length of the brood; and the same is shown graphically in fig. 6, together with the date of extreme first and last appearance in the four years.

Table 37 shows the sum of the squares of departures for all four years, for each species, for each of the points. It will be seen that the average variability (sum of squares of departures) for all species is largest for the first date (188), smaller and practically identical for the 25% and 50% dates (137 and 138), and very slightly larger (143) for the 75% date. The variability of the last date (183) is nearly as large as that of the first date. The error of the mean, however, differs by less than one day in all five calculations.

TABLE 37.

Variability of certain fixed points during the brood of some species of Lepidoptera.

	First	25%	50%	75%	Last	Mean
S. menthastri	203	219	159	55	21	133
P. forficalis (1st)	471	**673**	206	129	137	323
S. lubricipeda	329	223	117	65	175	182
R. tenebrosa	627	113	95	75	222	226
A. exclamationis	85	181	159	149	254	170
N. primulae	45	62	70	21	22	44
M. fasciuncula	61	45	39	38	103	57
C. perlellus	109	93	69	103	146	104
N. roborana	337	105	285	240	50	203
X. monoglypha	77	89	260	121	390	187
P. costalis	35	66	*5*	135	48	54
C. tristellus	21	61	182	314	129	141
L. impura	65	75	91	183	159	115
P. similis	81	68	277	239	125	158
A. grossulariata	**837**	197	126	159	325	331
L. lurideola	66	56	87	241	78	108
A. secalis	93	59	103	105	148	104
C. matura	83	97	89	167	58	99
B. ruralis	229	349	170	204	250	240
L. testacea	200	70	127	154	**525**	215
P. forficalis (2nd)	259	163	**441**	**463**	327	331
N. xanthographa	27	25	19	*6*	117	39
H. micacea	441	463	341	332	324	**380**
N. c-nigrum (2nd)	162	153	196	121	166	162
E. popularis	46	*10*	31	25	*9*	*24*
A. lunosa	*11*	58	61	61	87	56
A. lychnidis	64	46	45	71	66	58
P. populi	197	20	21	41	651	188
Mean sum of squares	188	138	138	143	183	158
Standard deviation	7·9	6·8	6·8	6·9	7·8	7·3
Error of mean	4·0	3·4	3·4	3·5	3·9	3·7

It would therefore appear that variability of date is a little less during the brood than at the first date. In other words, there is a slight tendency for the species to compensate for unusually early or unusually late dates, emergence taking place rather more rapidly after a late first date, and rather more slowly if the first date is early.

An examination was made to see if there was any relation between variability and the length of the brood. There was a positive correlation of 0·23 which, however, is not significant for the twenty-eight values available.

The mean length of the brood of the twenty-eight species dealt with in Table 36 is 41·9 days. The mean length of the first quarter is 13·8 days; of

the second quarter 6 days; of the third 6·2 days, and of the last 15·9 days. It would appear, therefore, that the emergence during the brood period is on an average almost symmetrical, half of the individuals being captured in the first 20 days and the other half in the following 22 days.

The Hours of Insect Activity During the Night.

It has already been explained that the light trap is provided with eight killing bottles which can be changed at predetermined intervals during the

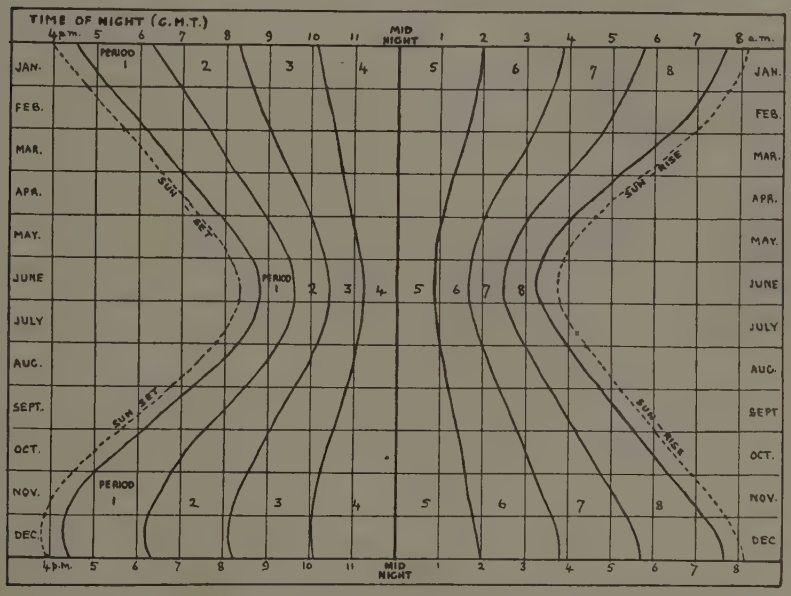

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Fig. 7.—Graphical representation of the hours of exposure of the eight killing bottles in the trap at different dates during the years.

night, so that the hours during which certain insects enter the trap can be found with some degree of exactness.

The bottles are not changed at the same hour throughout the year, but the times are altered once a week so that each bottle occupies as nearly as possible one-eighth of the hours of darkness. This is considered as lasting from half an hour after sunset to half an hour before sunrise. Period 1 always, therefore, has the dusk- and Period 8 the dawn-flying insects, and the change from 4 to 5 is always at midnight.

Fig. 7 shows graphically the hours of change throughout the year, and from this the time (G.M.T.) can be found at which any bottle is exposed in any month of the year. The shortest duration for each bottle is about 55 minutes at mid summer and the longest about 1 hr. 50 minutes at mid winter.

In a previous paper (Williams 1935) an account has been given of the results of the first two years work of the trap in relation to the distribution of

insects throughout the night. These results can now be extended to cover four years, and it is interesting to note how little change is required in the conclusions previously reached.

Distribution of All Insects.

Taking first the general distribution of all insects together in the eight periods of the night, Table 38 shows the distribution in the four years on both number and log. basis.

TABLE 38.

Distribution of all insects in the eight periods of the night for each year and for all four years; on number and log. basis.

Year	No. of nights	Period of night							
		1	2	3	4	5	6	7	8
		Sum of numbers							
1933–34	330	16,166	**16,179**	15,226	13,009	13,534	10,987	10,169	*8,691*
1934–35	296	**14,185**	11,631	10,298	9,552	10,780	8,288	*7,692*	10,635
1935–36	339	30,946	50,673	50,861	**55,980**	40,060	32,446	31,510	*20,275*
1936–37	294	31,785	**36,839**	31,735	24,943	23,816	18,325	*17,464*	22,314
Total	1259	93,082	**115,322**	108,820	103,484	88,190	70,046	66,835	*61,815*
Mean per night		73·9	91·6	86·4	82·2	70·0	55·6	53·1	49·1
		Sum of logarithm $(n + 1)$							
1933–34	330	**303·8**	289·6	270·6	255·8	254·4	239·2	227·9	*218·3*
1934–35	296	**343·8**	281·4	250·3	241·3	233·9	224·3	*207·9*	221·3
1935–36	339	**381·0**	338·8	323·7	316·0	295·6	275·6	*274·9*	275·1
1936–37	294	**321·4**	286·7	271·4	254·0	237·1	*227·1*	228·1	253·8
Total	1259	**1350·0**	1203·7	1116·0	1067·1	1021·0	966·2	*938·8*	968·5
Mean log. per night		1·072	0·956	0·886	0·848	0·811	0·767	0·746	0·769
Mean no. per night		10·8	8·0	6·7	6·0	5·5	4·8	4·6	4·9

It will be seen that on the number basis the maximum catch is in period 2 in 1933, in period 1 in 1934, in period 4 in 1935 and in period 2 in 1936. It should be noted that 1935, which gave the latest maximum, had the greatest total catch, while 1934, which gave the earliest maximum, had the smallest total catch. This agrees with results previously brought forward that on nights of large catches the maximum catch is later in the night than on nights of small catches.

The minimum catches are in period 8 in 1933 and 1935, and in period 7 in 1934 and 1936.

The average for the whole four years (see also fig. 8) gives the maximum in period 2 and the minimum in period 8. The minimum catch is just above half the maximum (54%).

On the log. basis the maximum catch is in the first period in all four years and the minimum catch in period 8 in 1933, in 7 in 1934 and 1935 and in 6 in 1936. All four years combined (see also fig. 8) give the maximum catch in the first period and the minimum in the 7th. The minimum catch is 43% of the maximum.

The variation in distribution from month to month in each of the first two years has already been given (Williams 1935 : 530). The results for the second two years support completely the conclusion of the first two and it seems unnecessary to give further figures in detail.

Instead I show in Table 39 the geometric mean catch in each of the periods of the night in each month, averaged over the whole of the four years.

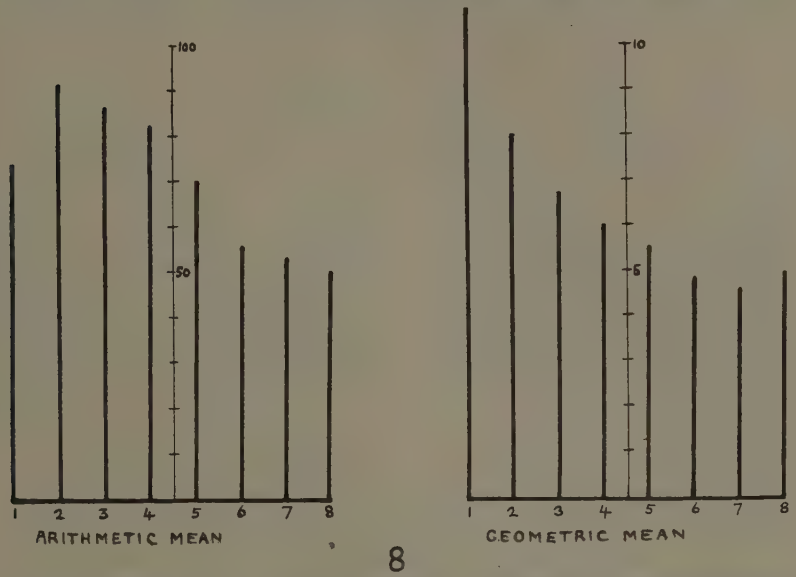

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FIG. 8.—Diagram showing the mean distribution of all insects in the eight periods of the night in all four years, in both number and log. basis.

It will be seen, for example, that the mean catch in the first period varies from 1·2 insects in February to 122 in August, while that in the last period

TABLE 39.

Geometric mean catch of all insects in each period of the night in each month, average for four years.

Period of night	1	2	3	4	5	6	7	8
March . . .	**2·0**	1·2	1·0	0·8	0·6	0·5	*0·5*	0·6
April . . .	**2·3**	1·1	1·0	0·7	0·8	0·7	*0·5*	0·6
May . . .	**13·8**	9·0	5·6	4·6	*3·5*	*3·5*	4·4	3·9
June . . .	**36·1**	**40·7**	25·9	23·0	22·4	17·2	*16·8*	17·6
July . . .	**69·8**	**111·2**	108·6	92·3	76·6	52·7	*43·7*	55·2
August . .	**122·0**	92·3	74·9	55·2	42·7	37·0	*29·2*	30·6
September . .	**39·7**	24·7	18·0	19·4	18·0	16·0	*13·5*	16·4
October . .	**12·2**	6·8	5·6	6·4	6·1	5·3	*4·5*	4·8
November . .	**10·5**	6·8	5·2	5·5	5·2	*4·4*	5·8	4·8
December . .	**2·7**	1·6	1·5	1·3	*1·0*	1·0	1·1	1·1
January . .	**1·5**	1·0	1·2	0·9	1·0	1·0	*0·8*	1·0
February . .	**1·2**	0·6	0·5	*0·5*	0·5	0·6	0·6	0·7

varies from 0·6 in March and April to 55 in July. The maximum is in the first period in each month except June and July, when it is in the second period. It should be noted, however, that although the August figures show on an

average of the four years a larger catch in the first period, there was in two out of the four years a larger catch in the second period, and the average result is strongly affected by very large catches in the first period in August 1934.

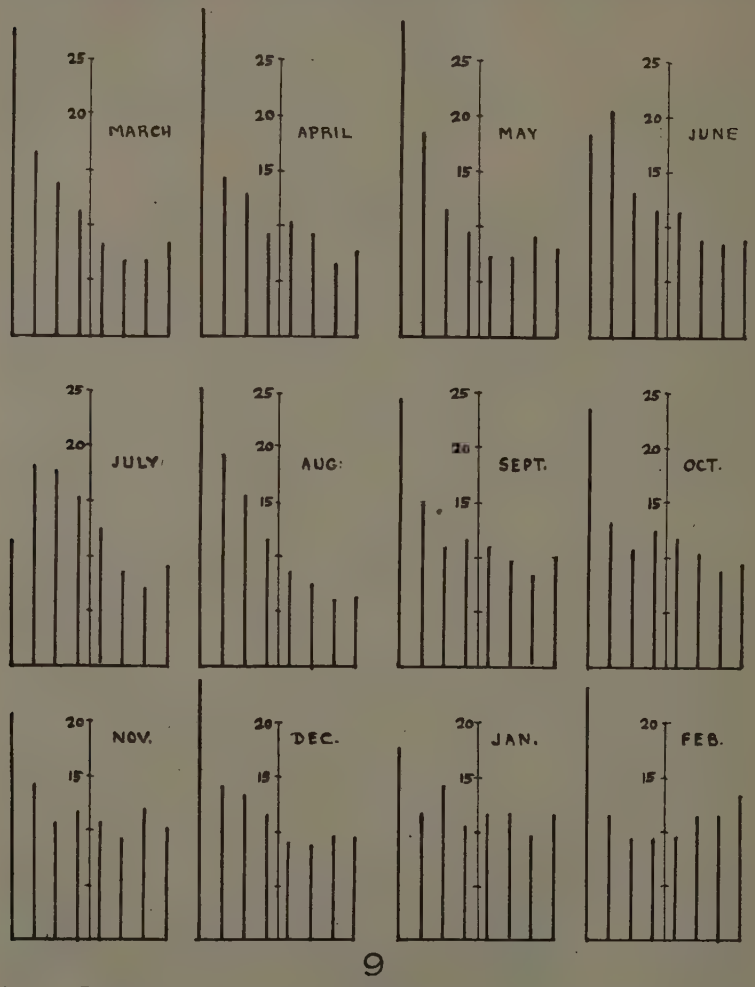

Fig. 9.—Diagram showing percentage of the total night's capture caught in each of the eight periods of the night. Average of four years for each month.

The variation in night distribution from month to month can be better understood by reference to Table 40 and fig. 9, which show the distribution in each of the eight periods expressed as percentages of the total catch for the night. Thus in March (average of four years) 27·8% of the night catch came in the first period; 16·7% in the second period, etc., and 8·3% in the last period.

From an inspection it will be seen that the three spring months, March, April and May, show high percentage catch in the first period followed by a steady fall to period 6 or 7, and then a slight rise.

TABLE 40.

Percentage of night's total caught during each period of the night in each month; average of four years.

Period of night	1	2	3	4	5	6	7	8
March	**27·8**	16·7	13·9	11·1	8·3	6·9	6·9	8·3
April	**29·9**	14·3	13·0	9·1	10·4	9·1	6·5	7·8
May	**28·6**	18·6	11·6	9·5	7·2	7·2	9·1	8·1
June	18·2	**20·5**	13·1	11·6	11·3	8·7	8·5	8·9
July	11·4	**18·2**	17·8	15·1	12·6	8·6	7·2	9·0
August	**25·2**	19·1	15·5	11·4	8·8	7·6	6·0	6·3
September	**24·2**	15·0	11·0	11·8	11·0	9·7	8·2	10·0
October	**23·6**	13·1	10·8	12·4	11·8	10·3	8·7	9·3
November	**21·8**	14·1	10·8	11·4	10·8	9·1	12·0	10·0
December	**23·9**	14·2	13·3	11·5	8·9	8·9	9·7	9·7
January	**17·8**	11·9	14·3	10·7	11·9	11·9	9·5	11·9
February	**23·1**	11·5	9·6	9·6	9·6	11·5	11·5	13·5

The summer months, June and July, show a very different type of distribution with a maximum in period 2. August shows a return to the spring type, but as has been explained there is some reason to believe that this result is not quite normal and should more closely resemble the June–July type.

The autumn months, September, October and November, show a high first period capture, then a rather sudden fall to period 2, and only a slight fall after this.

The winter months, December, January and February, show an exaggeration of the autumn type and in January and February the last period is as high or higher than the second.

There is a very definite and sudden change from February which is the culmination of the winter type to March which is definitely of the spring type.

The following suggestions seem to be possible explanations of some of the above results.

In summer the night temperatures are sufficiently high to enable activity to continue later and on the warmest nights optimum conditions may not occur until some time after dusk.

In the winter months one gets a somewhat complicated state of affairs. The larger catches tend of course to come on the warmer nights, but on an average the warmer nights are windy (often very windy) while the still nights, on the contrary, are cold. The combined effect is that the really large catches in these months often come on nights which have started warm and windy, and later in the night the wind has dropped, resulting in a sudden rush of insects into the trap.

As an example of this one may take the night of the 11th January 1934. On this night the catches in the eight successive periods were :—

0 : 0 : 0 : 0 : 0 : 0 : 25 : 402.

The minimum temperature of the night was 6·5° F. above normal, but the wind was up to and above 20 miles per hour until about 3 a.m., when it suddenly

Table 41.

Night distribution of certain species of Lepidoptera in each of the four years.

C. mendica								*P. gamma*							
0	0	0	0	1	2	4	0	0	0	0	0	0	1	1	0
0	0	0	0	0	2	8	5	1	5	0	0	1	0	1	0
0	0	0	0	0	2	2	3	2	1	1	1	3	3	2	3
0	0	0	1	0	0	2	1	5	1	0	2	2	1	2	2
E. lurideola								*C. brumata*							
1	2	3	3	17	36	15	22	7	26	4	5	1	0	0	0
1	4	1	11	26	41	29	13	41	10	8	7	14	10	12	3
2	1	8	10	13	7	16	6	2	3	1	1	2	4	0	1
1	1	2	2	8	9	6	1	10	2	2	0	3	0	2	0
C. potatoria								*C. pyraliata*							
1	8	7	4	1	0	0	0	1	0	3	4	7	3	3	0
1	6	2	4	0	0	0	0	1	0	4	5	9	9	2	3
3	2	6	0	2	0	0	0	0	4	7	13	19	7	2	0
1	1	1	0	0	0	0	0	0	0	0	3	4	1	1	0
H. lupulinus								*X. fluctuata*							
8	6	0	0	0	0	1	1	5	15	19	13	12	3	2	3
10	6	0	0	1	0	0	1	2	4	13	4	6	6	0	2
93	2	1	2	2	1	3	11	6	18	22	25	14	11	4	1
19	3	2	1	0	1	0	0	2	5	11	8	3	0	2	4
A. exclamationis								*O. luteolata*							
1	3	10	13	29	24	7	3	12	8	14	8	13	7	5	0
2	8	11	29	43	26	19	5	1	6	1	3	4	3	2	2
9	36	178	253	512	422	314	70	3	9	7	10	5	4	4	0
2	3	7	37	31	30	20	35	0	2	5	4	1	1	0	2
E. popularis								*S. lutealis*							
0	15	8	0	1	0	0	0	1	2	1	0	6	2	7	16
37	45	6	6	3	3	1	2	0	2	0	0	1	2	7	6
44	49	12	4	8	4	2	2	1	2	2	1	2	6	8	2
6	15	6	0	2	0	0	1	1	0	0	1	1	1	0	0
A. secalis (♂♂)								*S. verticalis*							
0	0	0	0	5	5	2	2	1	0	2	5	1	2	4	1
0	0	0	0	1	2	1	0	1	3	6	3	5	1	0	0
4	14	14	19	33	25	16	4	1	4	7	10	11	10	12	0
0	2	0	4	2	0	2	0	0	0	1	0	2	1	0	1
A. secalis (♀♀)								*C. tristellus*							
2	5	1	2	0	0	0	1	32	127	160	158	103	74	49	67
6	9	0	2	0	2	0	1	225	309	288	230	170	158	152	159
0	12	16	8	3	9	6	5	222	630	1014	722	489	372	302	187
0	2	3	0	1	0	1	0	33	86	137	146	81	73	39	24
X. monoglypha								*P. monodactylus*							
3	3	2	3	2	9	2	1	2	6	1	1	3	0	0	7
2	10	17	20	14	10	4	6	8	14	10	8	6	7	7	24
5	18	55	83	146	150	74	22	1	8	10	8	7	4	6	13
0	3	3	3	4	1	0	0	0	2	1	0	0	1	1	0
L. pallens								*A. bergmanniana*							
4	3	11	13	9	17	11	3	20	13	3	2	6	0	1	0
7	3	4	11	9	9	0	4	12	9	7	3	0	1	1	1
2	4	9	11	9	5	2	0	5	3	3	1	0	0	0	0
0	0	0	1	2	0	0	0	—	—	—	—	—	—	—	—
C. alsines								*N. roborana*							
0	0	1	6	3	0	0	0	1	2	2	8	40	40	27	8
0	1	1	7	3	5	2	0	5	6	15	38	55	23	15	7
1	2	7	23	30	14	9	0	3	1	16	23	70	35	17	1
1	0	1	2	4	2	0	0	0	0	4	12	9	3	0	0
T. gothica								*A. striana*							
0	8	9	7	11	11	3	3	4	4	3	3	6	4	17	126
0	1	0	1	5	6	16	5	21	6	3	5	3	10	30	204
0	1	4	6	3	9	6	2	12	21	7	3	9	13	54	175
3	1	0	1	0	2	1	0	0	2	3	0	1	2	17	47
A. lychnidis								*P. maculipennis*							
3	8	26	70	72	77	30	4	27	58	82	67	53	30	27	14
10	17	26	32	24	15	9	5	31	109	77	80	86	39	40	20
17	30	40	73	43	6	12	1	110	294	272	154	120	87	75	15
0	5	6	7	4	1	1	0	8	47	44	38	20	16	12	10

dropped and almost calm conditions followed. The effect of this night on the January average is obvious when it is noted that only 73 insects were captured on all the remaining nights of the month.

As a result of several similar occurrences the total catch on the number basis in the last period in January has been the maximum in two out of the four years, and on the log. basis the effect is shown by the flattening out of the curve. The high value for the first period on the log. basis is in fact due to a large number of small catches, as insects come in the first period on the poorer nights. The relatively high value for the later periods is due, on the contrary, to a small number of large catches.

Night Distribution of Some Species of Lepidoptera.

In the paper previously quoted figures were given showing the time of flight at night of fifty-six species of Lepidoptera, based on the results in the two years 1933 and 1934.

Figures for all these species are now available for 1935 and 1936, and some typical examples of the results for all four years are given in Table 41.

It will be seen, for example, that in *D. mendica* only one individual has been captured before midnight and the peak flight, on small total numbers, has been in three years in period 7 and in one year in period 8. *L. lurideola* is another late flyer with maxima in three years in period 6 and in one year in period 7.

O. potatoria is, on the contrary, an early flyer with maxima in periods 2 and 3 and only three individuals captured after midnight.

H. lupulinus is a very definitely early (dusk) flyer with maxima in period 1 on all four years and slight evidence of a renewed activity at dawn.

E. popularis is another example of great regularity with the maximum number in period 2 in all four years.

A. secalis is a good example of the difference in time of flight between the two sexes as discussed on p. 104.

On the whole, it is remarkable how closely the results in the different years resemble one another.

An examination of all the figures for fifty-four species in which the numbers were sufficiently high shows the following results :—

In 7 species (13%) the maxima were in the same period in all four years.
In 24 species (43%) the maxima were all within two adjacent periods.
In 12 species (21%) the maxima were all within three adjacent periods.

That is to say, that three-quarters of the species investigated showed a definite period of maximum flight within the limits of measurement of the apparatus used.

Table 42 shows the combined results for all four years of the captures in each period of the night for seventy-four species of Lepidoptera arranged according to the families in which they occur.

The numbers of species with maximum numbers in each successive period of the night are as follows :—

Period . .	1	2	3	4	5	6	7	8
Species . .	7	12	9	11	21	10	1	5

The largest number of species have their maximum flight in period 5, but there is evidence of two subsidiary peaks in period 2, the early flyer; and period 8, the dawn flyers.

Finally in Table 43 is shown diagrammatically the eight periods of the night and the species which reach their maximum in each. This is for comparison with a similar diagram published (Williams 1935) on the results of two

TABLE 42.

Night distribution during the four years of seventy-four species of Lepidoptera which came in sufficiently large numbers.

Species	Period of night							
	1	2	3	4	5	6	7	8
LYMANTRIIDAE								
P. similis . .	5	6	19	27	**46**	38	28	15
LASIOCAMPIDAE								
M. neustria .	0	2	7	42	**57**	14	13	5
P. populi . .	20	**29**	16	11	10	5	13	11
C. potatoria .	6	**17**	16	8	3	0	0	0
DREPANIDAE								
C. glaucata .	4	5	9	13	16	11	8	3
ARCTIIDAE								
S. menthastri .	5	13	45	**121**	106	44	18	7
S. lubricipeda .	2	9	13	22	33	**53**	37	16
D. mendica .	0	0	0	1	1	6	**16**	9
LITHOSIIDAE								
L. lurideola .	5	8	14	20	64	**93**	66	42
HEPIALIDAE								
H. sylvina . .	**25**	0	1	7	7	6	1	3
H. lupulinus . .	**130**	17	3	3	3	2	4	14
NOCTUIDAE								
A. exclamationis .	14	50	206	332	**615**	502	360	113
N. c-nigrum .	55	51	103	98	**114**	48	54	18
N. primulae .	0	2	10	**22**	17	19	8	2
N. rubi . .	11	26	61	**69**	21	12	4	1
N. xanthographa	**243**	114	65	50	44	21	14	11
E. popularis .	87	**124**	32	10	14	7	3	5
L. testacea .	30	58	62	67	106	**135**	93	21
C. matura . .	4	8	28	**41**	39	34	21	18
A. secalis, ♂ .	**4**	16	14	23	**41**	32	21	6
A. secalis, ♀ .	8	**28**	20	12	4	11	7	7
M. strigilis .	8	17	18	**19**	16	7	4	1
M. fasciuncula .	1	**51**	44	18	9	4	1	1
M. bicoloria .	**73**	56	55	38	8	3	8	5
X. monoglypha .	10	34	77	109	166	**170**	80	29
H. micacea .	2	5	12	**19**	10	7	7	3
L. pallens . .	13	10	24	**36**	29	31	13	7
L. impura .	16	43	**54**	35	28	19	12	6
L. comma . .	1	4	8	13	**27**	17	5	3
L. conigera .	5	10	17	17	**29**	20	7	11
G. trigrammica .	0	3	5	8	**27**	20	8	0
C. morpheus .	1	9	8	17	**18**	5	2	2
C. alsines . .	2	3	10	38	**40**	21	11	0
C. taraxaci .	0	1	1	4	**14**	5	6	2
R. tenebrosa .	1	4	5	37	**42**	20	2	4
T. gothica . .	3	11	13	15	19	**28**	26	10
A. lunosa . .	16	18	17	56	93	**136**	102	28
A. lychnidis .	30	60	98	**182**	143	99	52	10
P. gamma . .	**8**	7	1	3	6	5	6	5

TABLE 42.—(*continued.*)

Species	Period of night							
	1	2	3	4	5	6	7	8
GEOMETRIDAE								
A. aversata	6	21	**23**	16	9	11	3	1
T. amata	3	5	8	10	8	**14**	10	4
C. brumata	**60**	41	15	13	19	14	14	4
C. pyraliata	1	4	14	25	**39**	20	8	3
C. fulvata	4	9	14	**16**	7	6	0	0
C. unidentaria	26	39	**55**	45	39	25	20	9
C. ferrugata	23	24	**32**	19	12	12	13	7
O. dilutata	3	0	3	22	**25**	13	5	2
X. fluctuata	15	42	**65**	50	35	20	8	10
P. alchemillata	2	8	33	**40**	35	19	14	2
E. oblongata	16	21	**31**	14	24	20	17	13
E. subfulvata	1	14	12	**18**	4	4	4	3
A. grossulariata	0	5	13	17	10	**19**	13	5
E. fuscantaria	2	6	7	8	8	**12**	7	9
O. luteolata	16	25	**27**	25	23	15	11	4
A. aescularia	2	**9**	6	7	6	2	2	2
S. clathrata	3	9	7	9	**14**	8	4	3
PYRALIDIDAE								
P. costalis	24	**60**	55	33	20	16	17	7
S. lutealis	3	6	3	2	10	11	22	**24**
B. ruralis	2	15	**42**	35	30	29	8	6
S. verticalis	3	7	16	18	**19**	14	16	2
P. forficalis	7	16	23	37	41	**65**	53	8
CRAMBIDAE								
C. perlellus	37	181	257	229	**270**	196	152	74
C. tristellus	512	1152	**1599**	1256	843	677	542	437
PTEROPHORIDAE								
P. monodactylus	11	**30**	22	17	15	12	14	**44**
TORTRICIDAE								
T. viridana	2	2	3	7	**9**	3	2	0
P. variegana	3	2	3	5	4	3	11	**56**
A. bergmanniana	**37**	25	13	6	6	1	2	1
N. roborana	9	9	37	81	**174**	101	59	16
A. lacunana	9	22	34	52	**91**	71	67	52
A. purpurana	4	**21**	12	5	8	5	2	13
A. striana	37	33	16	11	19	29	118	**552**
A. lundana	0	1	1	1	0	1	28	**68**
E. hamana	62	**161**	120	68	23	12	8	10
TINEIDAE								
P. maculipennis	176	**508**	475	339	279	172	154	59
C. quercana	8	**28**	23	16	9	7	2	5

years work. A few species have been added, but as a result of two more years data scarcely any changes have had to be made in the positions of the species previously deal with.

Neuroptera.

The Neuroptera captured in the trap in the years 1933 and 1934 have been discussed by Williams and Killington (1935).

Table 44 shows the figures for the night distribution of the two families and for three species : unfortunately none of the species came in large numbers.

Table 43.

Table showing the eight periods of the night into which the catch was separated by the traps and the species of Lepidoptera which reach their maximum flight in each. Based on four years results.

	Period of night							
	1 (Dusk)	2	3	4 (Midnight)	5	6	7	8 (Dawn)
Lymantriidae					*P. similis*			
Lasiocampidae		*O. potatoria* *P. populi*			*M. neustria*			
Drepanidae					*C. glaucata*		*D. mendica*	
Arctiidae				*S. menthastri*		*S. lubricipeda*		
Lithosiidae						*L. lurideola*		
Hepialidae	*H. lupulinus* *H. sylvina*							
Noctuidae	*N. xanthographa* *M. bicoloria*	*E. popularis* *A. secalis* (♀) *M. fasciuncula*	*L. impura*	*N. rubi* *H. micacea* *M. strigilis* *A. lychnidis* *N. primulae* *L. pallens*	*C. morpheus* *C. alsines* *C. matura* *C. taraxaci* *A. exclamationis* *N. c-nigrum* *A. secalis* (♂) *L. comma* *L. conigera* *G. trigrammica* *X. monoglypha* *R. tenebrosa*	*L. testacea* *A. lunosa* *T. gothica*		
Geometridae	*C. brumata*	*E. oblongata* *A. aescularia*	*C. ferrugata* *C. unidentaria* *A. aversata* *X. fluctuata* *O. luteolata*	(*P. alchemillata*) *C. fulvata* *E. subfulvata*	*C. pyraliata* *S. clathrata* *D. dilutata*	*T. amata* *E. fuscantaria*		
Pyralidae		*B. costalis*	*B. ruralis*	*S. verticalis*		*P. forficalis*	*S. lutealis*	
Crambidae			*C. tristellus*		*C. perlellus*			
Pterophoridae		*P. monodactyla* (1)						*P. monodactylus* (2)
Tortricidae	*A. bergmanniana*	*A. purpurana* *E. hamana*			*A. lacunana* *T. viridana* *N. roborana*			*A. striana* *P. variegana* *A. lundana*
Tineidae		*P. maculipennis* *C. quercana*						

TABLE 44.

Period	1	2	3	4	5	6	7	8	Before mid-night	After mid-night
All HEMEROBIIDAE .	7	10	6	2	5	2	1	1	25	9
B. subnebulosa .	3	7	4	2	4	2	1	1	16	8
All CHRYSOPIDAE .	3	3	2	4	6	7	5	10	12	28
C. carnea . .	2	1	0	2	2	5	1	5	5	13
C. albolineata . .	0	2	1	2	1	1	3	2	5	7

The only striking feature is that the HEMEROBIIDAE are definitely early flyers (25 before midnight and 9 after), while the CHRYSOPIDAE are later flyers (12 before midnight and 28 after).

SUMMARY.

A light trap of approximately 300 c.p. was exposed in the fields at Rothamsted Experimental Station, almost every night from March 1933 to February 1937. The light was about 3 feet 6 inches (106 cm.) from the ground.

The total numbers of insects captured in each of the four years were 109,344; 103,362; 399,006; and 242,822. The arithmetic mean catches per night were 310, 287, 1102, and 728 respectively, but the geometric means which are believed to give a better indication of comparative abundance were 37; 53; 54, and 64. The highest catch in a single night was 73,100 on the 30th June 1935.

On the geometric mean basis the highest average catch was in July (723 insects) and the lowest in February (4·2 insects) on an average of all four years.

Diptera constituted 86·7% of the catch. Lepidoptera 10·3%, while all other insects only constituted 3%. The distribution of all orders in the different months is discussed more fully.

Among the Lepidoptera 356 species of Macrolepidoptera were captured, which is just over one-third of the known British species. Several species were new to the local fauna. There was practically no evidence that the trap markedly reduced the population, except possibly in one Geometrid moth.

A light trap at a height of 35 feet (10·6 metres) caught several species of NOCTUIDAE which were absent or rare in the lower trap.

Seventy-four species of Heteroptera were captured, of which fifty-seven were CAPSIDAE. This is almost one-third of the known British species of CAPSIDAE.

The majority of Lepidoptera come to the trap with a considerable excess of males over females, but this is not an absolute rule, and some species give an excess of females. The sex proportion in a number of species is listed.

In the TIPULIDAE (Diptera) the sex ratio varied from species to species and even the closely related species *Tipula paludosa* and *T. oleracea* give opposite results.

In CHRYSOPIDAE and HEMEROBIIDAE there is an excess of females and in the Heteroptera an excess of males.

Certain species of Lepidoptera are shown to vary considerably in the sex ratio from year to year and there is also slight evidence of different sex ratios in the individuals captured from different broods.

The proportion of females caught increases in many species during the course of the brood.

In the Lepidoptera there is evidence in many species that a higher proportion of females are caught before midnight than after. The same appears to be true in the Neuroptera, but in the Diptera some species show a higher and some a lower proportion before midnight.

In a trap placed on a roof at a height of 35 feet from the ground more species and individuals of NOCTUIDAE were captured than near the ground, and the individuals included a considerably higher percentage of females. The difference was more marked in some species than in others.

When the trap was removed from the roof and placed on a tripod immediately above the ground trap, but at the same height as the roof, the numbers of individuals of NOCTUIDAE fell very considerably, but the relatively high percentage of females in the captures remained.

It was found that in certain NOCTUIDAE females were in a higher percentage on nights when the moths were rare and relatively much fewer when the moths were common. Also in all the species of this family there was on an average a lower proportion of females caught in the common species than in the rarer ones.

The sequence of broods in a number of species of Lepidoptera is discussed and it is shown that in general first dates were early in 1933 and late in 1935 and 1936.

There is slight evidence that the NOCTUIDAE have a lower variability of date than the other groups and also slight evidence of a seasonal change in variability.

The date of first appearances, usually taken for phenological purposes, has the advantage of convenience but is more variable than other points later in the brood, such as, for example, the date on which 25 or 50% of the total captures have appeared.

Work on the time of flight of insects at night, on which two years data had previously been published, is reviewed in the light of two more years work. Nearly all previous conclusions are found to hold. For all four years on a log. basis the highest catch is in period 1 and the lowest in period 7. Evidence is, however, brought forward to indicate a seasonal change of distribution.

The time of flight of a number of species of Lepidoptera is discussed and it is found that there is a tendency for the peak flights to occur in periods 2, 5 and 8.

In the Neuroptera, the HEMEROBIIDAE tend to fly into the trap early in the night and the CHRYSOPIDAE later.

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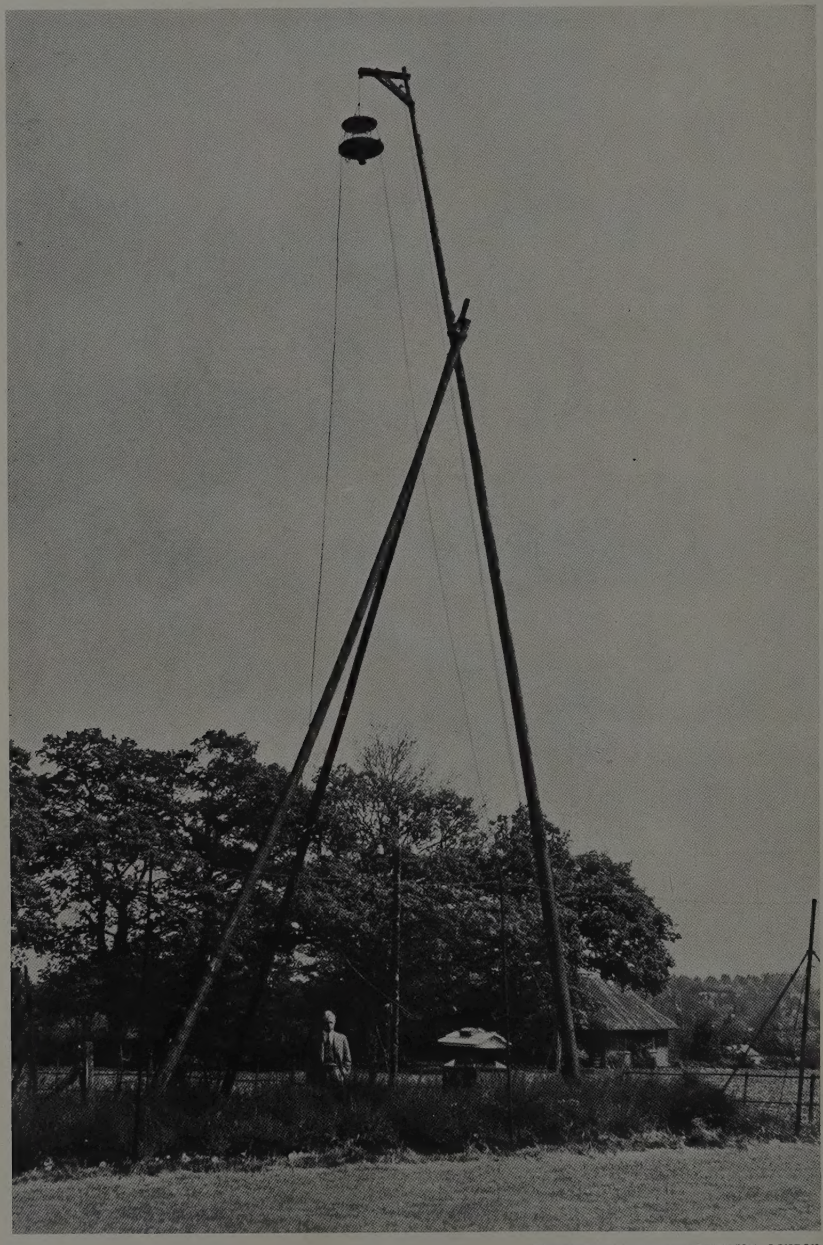

ENGRAVED BY STAR ILLUSTRATION, LONDON.

Upper and lower light traps at Rothamsted.

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Plate 1.

Photograph showing the upper and lower traps as used at Rothamsted. The upper trap at a height of 35 feet (10·6 metres); the lower at approximately 3 feet 6 inches (106 centimetres).